UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Note to Reader

Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply. EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.

The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, If unacceptable risks are identified, EPA will act to reduce or eliminate the risks.

There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

Note: This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket (RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

Jack E. Housenger, Acting Director
Special Review and Reregistration Division

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TOXIC SUBSTANCES

October 6, 1999

Memorandum

SUBJECT: AGRICULTURAL AND OCCUPATIONAL EXPOSURE ASSESSMENT AND RECOMMENDATIONS FOR THE REREGISTRATION ELIGIBILITY DECISION DOCUMENT FOR CHLORPYRIFOS

FROM: Tim Leighton, Environmental Health Scientist
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DP Barcode:	D259614
Pesticide Chemical Codes:	059101
EPA Reg Nos:	62719-38, -221, -23, -245, -34, -79, -72, -166, -220; 34704-66; 499-367, and 10350-22
EPA MRID No.:	430279-01, 429745-01, 431381-01 and 02, 444835-01, 430420-02, 429944-01 and 02, 430627-01 and 02
PHED:	Yes, Version 1.1

AGRICULTURAL EXPOSURE/RISK ASSESSMENT AND CHARACTERIZATION

EXECUTIVE SUMMARY

This document contains the occupational exposure assessment for agricultural, animal premise, and ornamental uses of chlorpyrifos. The document also includes potential risk mitigation measures such as personal protective equipment (PPE) and engineering controls for handlers and proposed restricted entry intervals (REIs) for postapplication activities. The scope of the document covers both Worker Protection Standard (WPS) and nonWPS uses including typical agricultural uses (e.g., citrus, vegetable crops, tree fruits, etc.), greenhouse uses, outdoor ornamental uses, and sodfarm uses. Exposures resulting from residential uses and exposures resulting from Pest Control Operators (PCOs) in residential settings are outside of the scope of this document.

Chlorpyrifos is an organophosphate insecticide used to control various insects such as grasshoppers, aphids, fire ants, etc. Chlorpyrifos is formulated as many end use products including products intended for agricultural uses, such as a wettable powder packaged in water soluble packets, granular, and soluble concentrate/liquids. The dry flowable formulation and the open packaging of wettable powders are no longer supported by the registrants, and therefore, not assessed in this document nor eligible for reregistration. A wide variety of application techniques have been identified that could potentially be used to apply chlorpyrifos, such as tractor-drawn equipment, open and closed mixing/loading, and hand held equipment. Applications of chlorpyrifos also include soil incorporated uses, bark treatments, and foliar treatments.

The application rates used in the assessment are intended to reflect the upper range of rates on the labels, and in some instances, the rates also include values Dow AgroSciences (DAS) specifically requested to be included as “typical”. DAS has recently submitted a market survey (Mar-Quest) and the Agency is currently reviewing the results before including additional characterization of chlorpyrifos typical use conditions. Examples of the application rates used in this assessment include, but are not limited to the following: vegetable crops range from 1 to 2 lb ai/acre; maximum citrus rate is 6 lb ai/acre; the maximum rates for tree nuts and fruits is 2 lb ai/acre; outdoor ornamental rates for wettable powders are up to 4 lb ai/acre and up to 0.16 lb ai/gallon for liquid formulations; and up to 8 lb ai/acre for fire ant control in sodfarm turf just prior to harvest. The predominant maximum application rates listed in Table 3 are defined as those rates which are most frequently cited in the labels and are also believed to be representative of the maximum allowable rates that would not underestimate exposure. Even though an attempt was made to include rates requested by DAS, some of the rates assessed do not necessarily reflect all of the typical rates used on those crops such as the tobacco rate (i.e., 5 lb ai/A).

Acute toxicity categories for the technical grade are Toxicity Category II for oral, dermal, and inhalation. It is a Toxicity Category III for primary eye and dermal irritation. The endpoints used in this document to assess chlorpyrifos hazards include short- and intermediate-term dermal

and inhalation endpoints. A route specific short-term dermal NOAEL of 5 mg/kg/day from a 21-day dermal rat study has been identified, and therefore, a dermal absorption adjustment is not necessary. The dermal LOAEL of 10 mg/kg/day is based on plasma and RBC cholinesterase inhibition (ChE) of 45 and 16 percent, respectively. The intermediate-term NOAEL used for dermal exposures is converted from an oral NOAEL of 0.03 mg/kg/day from a 2-year dog feeding study using a dermal absorption of 3 percent. Plasma and RBC cholinesterase inhibition occurred in this study at a dose level of 0.1 mg/kg/day (LOAEL). The short- and intermediate-term inhalation NOAEL is 0.1 mg/kg/day from two separate 90-day rat inhalation studies. There were no effects seen in both of these studies at the highest dose levels tested. However, at higher oral doses of 0.3 mg/kg/day RBC ChE was observed in animals. A lung absorption of 100 percent is used in the calculations (i.e., inhalation absorption is assumed to be equivalent to oral absorption). An uncertainty factor of 100 is used for all endpoints (i.e., 10x for intra species and 10x for interspecies variability). Thus MOEs of greater than 100 do not exceed the Agency's level of concern.

The exposure duration for short-term assessments is 1 to 7 days. Intermediate-term durations are greater than 7 days to several months. Although information is not available to determine what percentage of applicators apply chlorpyrifos for more than 7 days, it is reasonable to believe that typical uses of chlorpyrifos by commercial operators may encompass an intermediate-term duration. Applications of chlorpyrifos at the maximum application rates for specific uses such as the fire ant rate for sodfarms just prior to harvest may be of a short-term duration. However, until the Mar Quest research study is reviewed, both the short- and intermediate-term assessments are included. Private applicators, in most instances, are not expected to apply chlorpyrifos for more than seven consecutive days. No chronic (i.e., more than 180 days per year) agricultural or ornamental uses have been identified.

Multiple **handler** exposure studies were conducted by the registrant and submitted to the Agency. The handler data collected included biological monitoring and passive dosimetry data. These data, along with surrogate data from the Pesticide Handlers Exposure Database (PHED) Version 1.1, were used to assess the potential exposures resulting from handling and applying chlorpyrifos. Potential exposures and internal doses were calculated using unit exposures (i.e., normalized to amount of active ingredient handled -- mg/lb ai handled) from both passive dosimetry and biological monitoring data multiplied by the amount of chlorpyrifos handled per day (i.e., lb ai/day). The amount of chlorpyrifos assumed handled per day was derived from the various application rates and the number of acres (or gallons of spray solution) that could be applied in a single day. Dermal and inhalation margins of exposure (MOEs) are presented separately along with a combined total MOE. The total MOE is used to assess the hazard.

The **results of the intermediate-term handler** assessments indicate that 11 of the 15 potential exposure scenarios provide at least one application rate with a total MOE(s) greater than or equal to 100 at either the **maximum PPE** (i.e., coveralls over long pants, long sleeved shirts, and chemical resistant gloves while using open systems) or using **engineering controls** (i.e., closed systems). In the majority of cases, it is dermal exposure rather than the inhalation

exposure driving the total MOEs. Within the 11 scenarios, not all of the application rates/crops have MOEs greater than or equal to 100. More specifically, the total MOEs for all the scenarios range from 1 to 3,100. In total, 59 MOEs were calculated for the various application rates. Based on the maximum level of protection (i.e., various levels of PPE or engineering controls) 6 MOEs are estimated to be less than 10; 33 MOEs are between 10 and 100; and 20 of the MOEs are greater than 100. There are insufficient information (e.g., dermal and inhalation exposure data) to assess the seed treatment uses, dip applications (e.g., preplant peaches, nursery stock), and dry bulk fertilizer applications to citrus orchard floors. These scenarios are of concern given the results from the other scenarios assessed.

Multiple **postapplication** exposure studies were also conducted by the registrant and submitted to the Agency. These studies also included biological monitoring and passive dosimetry data, along with dislodgeable foliar residues (DFRs). Data were collected for sugar beets, cotton, sweet corn, citrus, almonds, apples, pecans, cauliflower, and tomatoes. These data were used in this assessment in conjunction with chemical-specific and HED standard values for transfer coefficients to assess potential exposures to workers reentering treated sites. All activities and crops that are potentially treated with chlorpyrifos have not been monitored. Therefore, in the absence of data the assessment of postapplication exposures in this document are based on a grouping of activities associated with various representative crops. The potential for dermal contact during postapplication activities (e.g., harvesting) is assessed using a matrix of potential dermal contact rates by activity and associated crops with groupings of "low", "medium", and "high". In addition to this matrix, citrus and tree nuts & fruits are assessed separately.

The **results of the intermediate-term postapplication** assessments indicate that REIs need to be established. The REIs range from 2 to 4 days for the "low" to "high" crop groupings. REIs for citrus and tree nut & fruit crops are up to 5 to 6 days for harvesting. A postapplication entry restriction of 4 days is necessary for scouts working in citrus and tree nut & fruit orchards. The timing of the applications are important to note because most of the applications to trees are to the bark during the dormant to early season. Even though there are insufficient information (e.g., timing of applications -- dormant/bark versus foliar treatments) and exposure data to assess postapplication activities for ornamental, sodfarm, and soil incorporated uses, these uses are believed to require similar REIs because of the high application rates and high potential for dermal contact.

The handler and postapplication assessments are believed to be reasonable high end representations of chlorpyrifos uses. There are, however, many uncertainties in these assessments. The uncertainties include but are not limited to the following:

- exposure of an intermediate-term duration to assess all uses;
- extrapolating exposure and DFR data by the amount of active ingredient handled or applied;
- not all of the exposure data are of high confidence because of the lack of replicates and/or

inadequate QA/QC in the studies;
- using crop-specific DFR data to assess other crops; and
- application timing in comparison to actual potential postapplication exposure scenarios.

These uncertainties are inherent in most pesticide exposure assessments. The conservative nature of the assessments, however, are believed to be protective of the handlers and reentry workers.

1.0 BACKGROUND

Purpose

In this document, which is for use in EPA's development of the Chlorpyrifos Reregistration Eligibility Decision Document (RED), EPA presents the results of its review of the potential human health effects of agricultural exposure to chlorpyrifos.

Criteria for Conducting Exposure Assessments

An occupational exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For chlorpyrifos both criterion are met.

1.1 Summary of Toxicity Concerns Relating to Agricultural Exposures

Acute Toxicology Categories

Table 1 presents the acute toxicity categories as outlined in the toxicity memorandum from D. Smegal to M. Hartman dated September 28, 1999 (D259611).

Table 1. Acute Toxicity Categories for chlorpyrifos

Study Type	Toxicity Category
Acute Oral Toxicity	II
Acute Dermal Toxicity	II
Acute Inhalation Toxicity	II
Primary Eye Irritation	IV
Primary Dermal Irritation	IV
Dermal Sensitization	NA

Other Endpoints of Concern

The Hazard Identification Committee memo, dated March 4,1999, indicates that there are toxicological endpoints of concern for chlorpyrifos. The endpoints, and associated uncertainty factors, used in assessing the risks for chlorpyrifos are presented in Table 2.

Table 2. Chlorpyrifos Hazard Endpoints and Uncertainty Factors.

Route / Duration	NOAEL (mg/kg/day)	Effect	Study	Uncertainty Factors	Comments
Short-term Dermal	5	Plasma and RBC cholinesterase inhibition of 45 and 16 percent, respectively, at 10 mg/kg/day	21-day dermal rat study	Intra species: 10x Interspecies: 10x	Dermal absorption not necessary
Intermediate-term Dermal	0.03	Plasma and RBC cholinesterase inhibition at 0.1 mg/kg/day	2 year dog study	Intra species: 10x Interspecies: 10x	3 percent dermal absorption.
Short- and Intermediate-term Inhalation	0.1	Lack of effects in 2 rat inhalation studies at the highest dose tested	Two 90-day rat inhalation studies	Intra species: 10x Interspecies: 10x	100 percent lung absorption assumed.

1.2 Summary of Use Pattern and Formulations

At this time some products containing chlorpyrifos are intended primarily for homeowner use, and some are intended primarily for occupational use. Only the occupational uses involving agricultural, animal premise, greenhouse uses, and sodfarms are addressed in this section.

Type of Pesticide/Targeted Pest/Use Sites

Chlorpyrifos [O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate], is an organophosphate insecticide currently registered for the control of various insects. Targeted pests include fleas, ticks, termites, cockroaches, cutworms, grasshoppers, aphids, etc. Registered use sites include grain crops, nut crops, Cole crops, citrus, pome and strawberry fruits, forage, field and vegetable crops, sodfarms, ornamental plants, and poultry, beef cattle, sheep, livestock premise treatments (direct application to animals are prohibited, except ear tags). It can also be used in greenhouses. There are a wide range of application rates. Typical vegetable crops range from 1 to 2 lb ai/acre (up to 2.75 lb ai/acre for radishes); granular applications up to 3.0 lb ai/acre for tobacco; greenhouse up to 0.0066 lb ai/gal and outdoor ornamentals as high as 0.16 lb ai/gallon (pine seedlings); sodfarm fire ant treatments up to 8 lb ai/acre; citrus 6 lb ai/acre; and tree nuts and fruits at 2 lb ai/acre. Tables 3 and 4 in the following sections below provide more detailed information on application rates, EPA Reg. Nos., crops, and associated application equipment types. A multitude of application rates have been assessed to provide additional characterization.

Formulation Types and Percent Active Ingredient

For the purposes of this chapter, relevant chlorpyrifos formulations include wettable powders packaged in water soluble packets (containing 50 percent a.i.), granular (containing 0.14 to 15 percent a.i.), impregnated ear tags, microencapsulated (containing 0.15 to 20 percent a.i.), and soluble concentrate/liquids (containing 0.5 to 62.5 percent a.i.). According to DAS, wettable powders packaged in open bags and dry flowables are no longer available and are being removed from active registrations. They are not assessed in this chapter and are no longer eligible for reregistration. The Agency will work with DAS to delete any other formulations and/or products that are obsolete.

1.3 Method and Types of Equipment Used for Mixing/Loading/Applying

The Agency determines potential exposures to pesticides handlers by identifying exposure scenarios from the various application equipment-types that are plausible given the label uses. Based on reviewing pesticide labels and professional judgement, the use patterns specific to chlorpyrifos are associated with the following application equipment:

- Aerial (Spray) Equipment: foliar applications to fruit/nut trees, cranberries, field crops (e.g., alfalfa, sorghum/Milo, wheat, soybeans, corn), cotton, vegetable crops, specialty crops (e.g., Christmas trees, mint, peanuts, sunflowers). Although sodfarms do use aerial applications, it is DAS contention that chlorpyrifos is not applied aerially to sodfarms. Aerial sodfarm applications are therefore not assessed and the label needs to be modified to prohibit aerial applications of chlorpyrifos.
- Aerial (Granular): corn, peanuts.
- Chemigation Equipment: field crops, cotton, cranberries, specialty crops, and ornamentals. The exposure to the handlers using chemigation equipment is represented by the mixer/loader and the amount handled is assumed to be equivalent to that of the aerial applications. Current chlorpyrifos labels prohibit chemigation on sodfarms; all sodfarm uses need to include this prohibition.
- Groundboom Equipment: fruit/nut orchard floors, cranberries, strawberries, field crops, cotton, vegetable crops, tobacco, outdoor ornamental soil treatment, sodfarm.
- Airblast Equipment: fruit & nut tree foliage and bark treatments.
- Backpack/Low Pressure Handwand Equipment: fruit/nut/ornamental tree bark treatments, grape vine-base treatments, stump treatments, outdoor/greenhouse ornamentals, and animal premises.
- High Pressure Handwand Equipment: greenhouse ornamentals.
- Hydraulic Sprayer with Handgun (i.e., rights-of-way type sprayer): fruit, nut, ornamental, Christmas tree bark/stump treatments, and animal premises.
- Dry Bulk Fertilizer: citrus floor (insufficient exposure data available to assess this use).
- Dip: peach/nectarine transplants (exposure data are not available to assess this use).
- Injector: potted/balled ornamental soil treatments (exposure data are not available to assess this use).

There is also a turfgrass/sodfarm use specifically listed on the label to be applied with a

"mistblower". The mistblower is used to treat low underbrush, grassy areas, weeds, etc., to control ticks and chiggers. The use is for non sodfarm areas and should be removed from any sodfarm labels. Sodfarm applications are represented and assessed by groundboom applications.

2.0 HANDLER EXPOSURES

2.1 Handler Exposures & Assumptions

EPA has determined that there are potential exposures to mixers, loaders, applicators, or other handlers during usual use-patterns associated with chlorpyrifos. Based on the use patterns and potential exposures described above, 15 major agricultural, animal premise, and/or greenhouse exposure scenarios are identified to represent the extent of chlorpyrifos uses.

Agricultural exposure scenarios include:
(1) mixing/loading the liquid formulation to support aerial, airblast, and groundboom applications,
(2) mixing/loading the wettable powder formulation to support aerial, airblast, and groundboom applications,
(3) loading the dry (granular) formulation to support aerial and ground applications,
(4) applying the liquid/wettable powder/granular formulations with aerial equipment,
(5) applying the liquid/wettable powder formulation with groundboom equipment,
(6) applying the liquid/wettable powder formulation with airblast equipment,
(7) applying the granular formulation with a tractor-drawn granular spreader,
(8) applying in commercial seed-treatment equipment,
(9) applying as a preplant-dip treatment,
(10) flagging for aerial spray applications,
(11) flagging for aerial granular applications,
(12) mixing/loading and applying with a back-pack sprayer,
(13) mixing/loading and applying with low-pressure hand-wand sprayer,
(14) mixing/loading and applying with a high pressure handwand (greenhouse uses), and
(15) mixing/loading and applying a spray application to tree-trunks using tractor/truck-mounted hand-held sprayers (i.e., similar to rights-of-way treatments).

The potential handler exposures to the 15 exposure scenarios are assessed in this RED chapter using the toxicological endpoints and uncertainty factors associated with the active ingredient. Therefore, the PPE and engineering controls are determined by the assessment of the active ingredient and not the currently required risk mitigation measures on chlorpyrifos labels. For example, if a label's PPE was previously determined using a human toxicological study and the associated 10x uncertainty factor, then the PPE may not be sufficiently protective given the Agency's current policy not to use human toxicological studies. This distinction of determining risk mitigation measures based on the active ingredient instead of the label required PPE is also important because of the nature of the end-use products. For example, some end-use products require additional PPE that are not necessary for the active ingredient because of the end-use product's potential for eye and/or skin irritation based on inerts. Conversely, the Agency does

not want to mandate additional PPE (e.g., heat stress issues) if it is not required based on the endpoint and uncertainty factors. Baseline attire (long pants, long sleeved shirt, and no gloves) is not presented in this chapter because of the need for additional PPE and/or engineering controls for all scenarios. There are some PPE, such as chemical-resistant aprons and/or head gear, that the Agency uses as qualitative measures because there are no recognized protection factors (PF) to assess their effectiveness. The Agency's risk managers require these types of PPE as additional mitigation. For example, chemical-resistant aprons are often required to protect mixer/loaders from accidental spills.

2.1.1 Submitted Studies

Mixer/loader/applicator exposure data for chlorpyrifos were required during the data call-in (DCI) on September 18, 1991, since one or more toxicological criteria had been triggered. Requirements for applicator exposure studies are addressed by Series 875 Group A (formerly Subdivision U of the Pesticide Assessment Guidelines). The following five handler exposure studies were submitted by the registrant and are summarized below.

- **MRID No. - 430279-01.** Contardi, J.S. et al. 1993. Evaluation of Chlorpyrifos exposures during mixing/loading and application of Empire*20 insecticide to ornamental plants in greenhouses.

  Passive dosimetry (dermal and inhalation) and biological monitoring (urine analysis) were conducted for 16 combined mixer/loader/applicator replicates. Of the 16 replicates monitored, 1 replicate was a low pressure handwand, 2 replicates were for backpack sprayers, and 13 replicates were for high pressure handwands. The applications were made at various heights (i.e., floor, bench, overhead) to ornamental plants in a greenhouse. To summarize, an insufficient number of replicates were monitored for low pressure handwand and the backpack sprayer application techniques to meet the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters and inhalation canisters; however, the laboratory recovery results for the hand rinses were highly variable (i.e., 118.0 +/- 23.9 percent). The quality control/quality assurance aspect of the biological monitoring is sufficient, except that field spikes were prepared for only 10 of the 16 replicates (minimum of 2 field spikes per day of sampling). The data available from this study are of sufficient scientific integrity to be used in combination with available surrogate data to assess the risk to those handlers.

- **MRID No. - 429745-01.** Shurdut, B.A. et al. 1993. Lorsban 4E and 50W insecticides: assessment of Chlorpyrifos exposures to applicators, mixer/loaders and re-entry personnel during and following application to low crops.

Passive dosimetry (dermal and inhalation) and biological monitoring (urine analysis) samples were collected for 9 replicates of open cab groundboom tractors, 6 replicates of open mixing of a 4EC formulation, and 3 replicates of open pour of a 50WP formulation. The applications were made at preplant on cauliflower and tomato plants. To summarize, an insufficient number of replicates were monitored for each formulation for mixing/loading and for groundboom application to meet the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters, hand rinses, and inhalation canisters. The quality control/quality assurance aspects of the biological monitoring were sufficient. The data available from this study are of sufficient scientific integrity to be used in combination with available surrogate data to assess the risk to those handlers

- **MRID No. - 431381-02.** Honeycutt, R.C. & Day, E.W. Jr. 1994. Evaluation of the potential exposure of workers to Chlorpyrifos during mixing and loading, spray application, and clean-up procedures during the treatment of citrus groves with Lorsban 4E insecticide.

  Passive dosimetry (dermal and inhalation) and biological monitoring samples (urine analysis) were collected for 15 open pour liquid mixer/loader replicates and 15 open cab airblast applicator replicates. The applications were made to citrus groves (i.e., lemons and oranges) at the maximum label rate of 6 lb ai/acre. To summarize, the study meets the acceptability criteria outlined in Subdivision U of the Pesticide Assessment Guidelines. The quality control/quality assurance aspects of the passive dosimetry were adequate for the dermal whole-body dosimeters and inhalation canisters; however, the field recovery results for the hand rinses are questionable (i.e., 131 percent). The quality control/quality assurance aspects of the biological monitoring were sufficient. The data from this study are of sufficient scientific integrity to be used in the assessment.

- **MRID No. - 444835-01.** R. F. Bischoff 1998. Evaluation of Chlorpyrifos exposure to workers during loading and application of Lorsban 15 % granular insecticide during corn planting.

  Passive dosimetry (dermal and inhalation) and biological (urine) monitoring samples were collected for 16 combined replicates of loading and applying Lorsban 15G during corn planting. The test subjects loaded the granular product in row planters (8 to 12 row planters) and accompanied the tractor driver (i.e., farmer) in the enclosed cab. The “simulated” applicator portion of the replicate does not appear to introduce any significant uncertainties in the results. Four of the replicates were monitored in Kentucky and the other 12 replicates were in Michigan. Lorsban 15G was applied at the typical rate of 8 oz./1,000 linear feet,

however, the row spacing was not reported (depending on the row spacing the rate is equivalent to 0.975 to 2.175 lb ai/A using 40 to 18 inch rows, respectively). The maximum rate (Reg. No. 62719-34) is 16 oz/1,000 linear feet which at an 18 inch row spacing would correspond to 4.35 lb ai/A. However, there is a use restriction on the Lorsban 15G label of a maximum of 13.5 pounds of product per acre for corn (i.e., 2 lb ai/A). Although the application rate in lb ai/acre could not be determined, it is not the maximum rate on the label. Replicates ranged from 2.6 to 5.9 hours. Dermal exposure was monitored using whole body dosimeters (total deposition) and T-shirts and briefs worn underneath the whole body dosimeters to measure penetration. Hand washes were used to monitor potential hand exposure. Inhalation exposure was monitored using personal air sampling pumps along with a sampling train consisting of cellulose ester filters with a Chromosorb 102 solid sorbent. Biomonitoring consisted of urine specimens collected at 12-hour intervals over a six day period. The urine was analyzed for 3, 5, 6-trichloropyridinol (TCP), the principal metabolite of chlorpyrifos in humans. Urinary creatinine was also measured to evaluate the completeness of each urine collection. The QA/QC aspects (e.g., field recoveries) were adequate. To summarize, the study meets the acceptability criteria outlined in Series 875 Group A (except the maximum rate was not used) and the results are presented in the assessment below.

- **MRID No. - 447393-02.** Knuteson et. al. 1999. Evaluation of Potential Exposure to Workers Mixing and Loading Lorsban-4E Insecticide Products for Aerial Application.

  Exposures were estimated based on both passive dosimetry measurements and biomonitoring of urinary 3,5,6-trichloro-2-pyridinol (TCP) (the primary metabolite of chlorpyrifos). This study characterizes exposures to 14 workers during the mixing and loading of Lorsban-4E or Lorsban 4E-SG, a 45% emulsifiable concentration insecticide for aerial application to cotton, alfalfa and wheat. Each worker mixed and loaded enough product to cover a 500 acre per day target rate (170 to 250 lb ai and 42.5 to 62.5 gallons product for wheat and 500 lbs ai and 125 gallons of product for cotton and alfalfa). Lorsban was applied at the maximum label registered application rates of 0.5 lb active ingredient (ai) per acre for wheat, and 1.0 lb ai per acre for cotton and alfalfa. The study examined exposures to a total of 15 workers, five for wheat in Dalhart, Texas, five for cotton in Gila Bend, Arizona and five for alfalfa in Gila Bend, Arizona. The mixing/loading exposure period ranged from 40 to 131 minutes, with an average of 89 minutes. The workers wore cotton overalls, a cotton T-shirt, brief, and socks, chemical resistant gloves, apron and knee-high boots, goggles and a hat during the mixing/ loading operation. The total absorbed doses estimated from biomonitoring ranged from 0 to 32 µg/kg BW, with an arithmetic mean of 3.61 ± 8.26 µg/kg BW, and a geometric mean of 1.32 µg/kg BW. The arithmetic mean values from the biomonitoring are three times higher than the arithmetic estimates from

dosimetry. Baseline (i.e., background) chlorpyrifos exposures ranged from 0.13 to 4.55 µg/kg with a mean of 1.13 µg/kg, despite the fact that workers were instructed to avoid chlorpyrifos exposure 10 days prior to the study initiation.

The majority of the exposure data meet the criteria specified in Series 875 Group A. Only minor issues were identified. The study evaluated 15 workers, however one the workers (ML13) dropped out of the study the day after exposure, and therefore was not included in the biomonitoring results.

In addition to these handler studies, three additional registrant-generated risk assessments were submitted using the collected data. The risk assessments are summarized below. As noted below, the results of these assessments are not used in the Agency's risk assessment.

- **MRID No. - 430420-02.** Chlorpyrifos: an exposure and risk assessment for workers/loading and applying Empire 20 insecticide to ornamentals in greenhouses.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No.430279-01. In the original exposure monitoring study cited in the registrant-generated assessment, Empire 20 was monitored during mixing/loading and applying chlorpyrifos to ornamental plants in a greenhouse. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The registrant-generated assessment included calculations of margins of safety and a Monte Carlo simulation. The registrant concluded that the probability for any of these workers to exceed the single or multiple NOAEL of chlorpyrifos is very small, and that this is confirmed by the absence of significant cholinesterase depression in the test subjects on the day after application. The application techniques (i.e., low pressure handwand, backpack, and high pressure handwand) were combined in the assessment because the registrant determined that there was no significant difference between exposures for test subjects applying to plants overhead versus plants on the bench or floor. The Agency is concerned with combining the low pressure handwands with the high pressure handwands along with the inconsistent use of protective clothing (e.g., some test subjects wore rainwear, respirators, and/or face shields). Furthermore, the Agency does not regulate at the NOAEL but rather beyond the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the raw data combined with other surrogate data to perform its own deterministic assessment.

- **MRID No. - 431381-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with airblast sprayer application of Lorsban 4E to high crops.

  This study is a risk assessment generated by the registrant based on the data submitted in

MRID No.431381-02. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E was monitored during mixing/loading and airblast application. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The registrant concluded that the probability for any of these workers to exceed the single or multiple NOAEL of chlorpyrifos is very small, and that this is confirmed by the absence of significant cholinesterase depression in the test subjects on the day after application. However, the Agency does not regulate at the NOAEL but rather beyond the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the data to perform its own risk assessment.

- **MRID No. - 429944-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with mixing/loading, application and reentry following ground boom application to low crops.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 429745-01. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E and LORSBAN 50W were monitored during mixing/loading, groundboom application, and reentry scouts. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposures as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOAELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results as reported in the registrant-generated assessment, based on a Student t-test statistical analysis, are as follows: (1) there is a finite probability (24.2%) for an individual who repeatedly mixes and loads LORSBAN 50W to exceed the NOAEL for multiple exposures to chlorpyrifos, and (2) there is a finite probability (1.06%) for an individual who repeatedly applies (groundboom) LORSBAN to exceed the NOAEL for multiple exposures to chlorpyrifos. However, the Agency does not regulate at the NOAEL but rather beyond the NOAEL based on uncertainty factors (e.g., 10x for intra-species and 10x for inter-species variations). Therefore, the Agency used the data to perform its own risk assessment.

2.1.2 Summary of Occupational Handler Exposures

Table 3 presents the exposure scenarios, application rates, and area (i.e., acres or gallons) potentially treated that have been used in the exposure calculations. Chlorpyrifos labels include a multitude of uses and a wide range of application rates. Therefore, the rates presented in Table 3

are not all inclusive and an attempt has been made to assess the higher application rates to ensure that the exposures are not underestimated. Once the Agency reviews the Mar Quest survey, additional application rates can be added to the assessment.

The results of the passive dosimetry and biological monitoring data are presented in Appendix A. The calculations for the short-term occupational assessment are not provided in this chapter because the uses of chlorpyrifos are believed to be better represented for commerical handlers by the intermediate-term (7 days to several months) exposure duration. However, the variables (e.g., rates, acres, and unit exposures) used to calculate the short-term exposures are identical to those provided in Appendix A, except that a dermal absorption rate was not used. The dermal absorption rate was not used because the short-term toxicological endpoint is from a dermal study. The results of the short-term MOEs are presented in a summary table (see Table 4).

The above chemical-specific exposure data are used in the Agency's assessment to assess the potential handler exposure to chlorpyrifos. PHED V1.1 has also been used to supplement the chemical-specific data and to assess the exposure scenarios which were not monitored by the registrant. HED's policy is to supplement chemical-specific data with available surrogate data in PHED to increase the sample size. This policy is in effect because individual chemical-specific studies do not necessarily encompass the variety of equipment in use throughout the country and the large variability of exposures among handlers. While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. PHED was designed by a Task Force of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts -- a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates).

Users select criteria to subset the PHED database to reflect the exposure scenario being evaluated. The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenarios (e.g., gloves, double layer clothing). Once the data for a given exposure scenario has been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest,

upper arm) is categorized as normal, lognormal, or “other” (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all “other” distributions. Once selected, the central tendency values for each body part are composited into a “best fit” exposure value representing the entire body.

Table 3: Exposure Variables for Agricultural Uses (Including Non WPS Ornamental Uses) of Chlorpyrifos.

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? [a]	Application Rates (lb ai/acre)[b]	Daily Acres Treated[c]
Mixer/Loader Exposure			
Mixing/Loading Liquids for Aerial and/or Chemigation Application (1a)	Yes (447393-02)	1.5 cranberries, corn (most crops at 1 lb ai/acre)	350
		3.5 citrus[d]	100
Mixing/Loading Liquids for Groundboom Application (1b)	Yes (429745-01)	1.5 predominant max / 5.0 tobacco max for nematodes in NC & SC	80
		2 & 4 sodfarm(2 lb ai/A rate also for tobacco and potatoes)	80
		8.0 sodfarm fire ants (harvest only)	<1 &10
Mixing/Loading Liquids for Airblast Application (1c)	Yes (431381-02)	2.0 predominant max such as Fruits & Nuts / 6.0 citrus	40
Mixing WP for Aerial Application (2a)	No	2.0 predominant max (orchards)	350
		3.5 citrus[d]	100
Mixing WP for Groundboom Application (2b)	Yes (429745-01)	1.0 predominant max (brassica)	80
		4.0 soil treatment ornamentals outdoors / 1.3 & 3.0 sodfarm	80
		8.0 sodfarm fire ants (harvest only)	<1 &10
Mixing WP for Airblast Application (2c)	No	2.0 predominant max (orchards) / 6.0 citrus	40
Loading Granulars for Aerial Application (3a)	No	1.95 maximum aerial rate	350
Loading Granulars for Ground Application (3b)	Yes (3a & 8 combined 444835-01)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80
Applicator Exposure			
Aerial (Spray) -- Enclosed Cockpit (4a)	No	2.0 Orchards (most crops at 1 lb ai/acre)	350
		3.5 citrus[d]	100
Aerial (Granulars) -- Enclosed Cockpit (4b)	No	1.95 max aerial rate	350
Groundboom Tractor (5)	Yes (429745-01)	1.5 predominant max / 5.0 tobacco max	80
		1.3 / 2 / 3 / 4 Sodfarm	80
		8.0 sodfarm fire ants	<1 & 10
Airblast Applicator (6)	Yes (431381-02)	2.0 predominant max (orchards) / 6.0 citrus	40
Tractor-Drawn Granular Spreader (7)	Yes (3a & 8 combined 444835-01)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80
Seed Treatment (8)	No	No Data	No Data

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? [a]	Application Rates (lb ai/acre)[b]	Daily Acres Treated[c]
Dip Application (Preplant Peaches) (9)	No	No Data	No Data
Flagger Exposure			
Spray Applications (10)	No	2.0 predominant max	350
		3.5 citrus[d]	100
Granular Applications (11)	No	1.95	350
Mixer/Loader/Applicator Exposure			
Backpack Sprayer (12)	Yes (430279-01)	0.0417 lb ai/gal predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day
		3.5 citrus bark	1 A/day
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	1,000 ft^2
Low Pressure Handwand (13)	Yes (430279-01)	0.0417 predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day
		3.5 citrus bark	1 A/day
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	1,000 ft^2
High Pressure Handwand (greenhouse uses) (14)	Yes (430279-01)	Min. 0.0033 lb ai/gal	1000 gal/day
		Max. 0.0066 lb ai/gal	
Hydraulic Hand-held Sprayer for Bark/Pine Seedling Treatment (15)	No	3.5 citrus bark	10
		0.08 lb ai/gal bark beetle treatment / 0.16 lb ai/ gal pine seedling treatment	1,000
		0.039 lb ai/gallon/750ft^2 animal premise fly treatment	10,000 ft^2
Dry Bulk Fertilizer Impregnation	No	1.0 lb ai / 200 lb fertilizer / acre	No Data

[a]Biological monitoring data are available from several chemical-specific studies (discussed in the text above) and these data are presented in Appendix B Table B4. Although biological monitoring scenarios are available for some of the scenarios as indicated in this table, passive dosimetry data are presented for comparison because insufficient replicates and/or additional risk mitigation measures were necessary.

[b]Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-38, -221, -245, -34; -79, -72, -166, -220, 34704-66 (Clean Crop Chlorpyrifos 4E -- sodfarm fire ant rate), 499-367 (499-367 is the only greenhouse label identified), and 10350-22 for animal premise treatments. **"Predominant max"** in this table refers to the most **frequently identified maximum** application rate found on the labels for the specific formulation and equipment type. Typical rates are also included to characterize the chlorpyrifos uses. Not all application rates are included for all crops, instead, a cross-section of rates are used to represent the uses of chlorpyrifos.

[c]Daily acres treated are based on HED's estimates of acreage (or gallonage) that would be reasonably expected to be

treated in a single day for each exposure scenario of concern. The sodfarm fire ant rate is restricted on the label for harvest only, therefore, this rate is limited to the amount of sod that may be harvested in a reasonable time frame. Therefore, using the limited data available, approximately 10 acres treated per day are assumed to be the upper range along with the median value of <1 acre.

[d]The application rates on the Lorsban 4E (EPA Reg. No. 62719-220) and 50W (EPA Reg. No. 62719-39 discontinued as of 1995 and sold as -221) labels indicate that for citrus at the 6.0 lb ai/A rate it is necessary to use 100 to 2,400 gallons per acre dilute spray. Therefore, this rate is not expected to be feasible for an aerial applicator. The label language should be clarified so that the 6.0 lb ai/A rate is for ground only. Additionally, citrus orchards are believed to be relatively small plots and 100 acres per day is assumed in the assessment for aerial applications.

2.1.3 Summary of Uncertainties

The handler exposure assessments encompass all of the major uses of chlorpyrifos throughout the country. It is difficult to assess all of the "typical" agricultural uses (i.e., actual or predominate application rates -- "predominate" being defined as the most frequently found rates on labels). DAS recently submitted a use survey (i.e., Mar Quest research study) to assist the Agency in determining how chlorpyrifos is used in the field. However, at the time that this chapter was developed, the Mar Quest study had just been received and its scope has not been reviewed. Once reviewed, the Agency will incorporate the appropriate information from this survey to better characterize chlorpyrifos risks for the Agency's risk managers. In the mean time, an assessment has been developed which is believed to be realistic and yet provides a reasonable certainty that the exposures are not underestimated. Some of the specific DAS requests for clarification and interpretation of product labels and application techniques are included. The assumptions and uncertainties identified below are included for characterization and transparency:

- *Application Rates:* Each exposure scenario includes the allowable maximum application rate that was identified on the available product labels. In addition, a range of application rates was used when the maximum application rates for various crops varied widely or when specific rates were requested by DAS to better characterize the scenario. The "predominant max" rate that is assessed is the most frequently found maximum application rate on the labels for the specific equipment type and formulation. Identifying the most frequently found maximum labeled application rate was accomplished by reviewing the products. Other than a national survey, there are no statistical techniques to determine what rates to include in an assessment -- other than always including the maximum rates. Therefore, DAS has requested that the Agency also include the actual rates identified in the Mar Quest research study for further demarcation of the risks. The Agency will further characterize the uses once the study is reviewed. In most instances, the maximum labeled application rates were applied to application techniques that are feasible given the amount of dilute spray that needs to be applied. For example, the citrus aerial maximum application rate is assessed at 3.5 lb ai/acre. The maximum citrus rate (i.e., 6 lb ai/A) requires a high volume of dilute spray (i.e., 100 to 2,400 gallons) which would not be practical in an aircraft. The labels should be clarified to reflect the maximum rate of 3.5 lb ai/acre for aerial application to citrus.

- *Amount Handled:* The daily acres treated or gallons applied are HED standard values (see Table 3) along with the amount of gallons that may be applied using handheld equipment. If the Mar Quest survey recently submitted by DAS provides reliable chemical-specific information on acreage treated, the Agency will revise these standard values using the high end of these distributions. Deviations from the HED standard values include the aerial acreage for citrus and the groundboom acreage for the sodfarm fire ant application rate. The citrus acreage is assessed at 100 acres because citrus orchards are grown in smaller plots. As for the sodfarm assessment, the Turfgrass Producers International's (TPI) membership-wide survey, for production year 1997, states that the median sodfarm is 350 acres (of which 235 acres in turf) and the estimated daily harvest during the peak months is 0.82 acres (median). The sodfarm fire ant rate is also assessed at 10 acres because this is believed to be a *reasonable maximum* area that can be harvested in a single day and/or the area a commercial applicator might apply to multiple sodfarms in a single day.

- *Unit Exposures:* The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. To add consistency and quality control to the values produced from this system, the PHED Task Force has evaluated all data within the system and has developed a set of grading criteria to characterize the quality of the original study data. The assessment of data quality is based on the number of observations and the available quality control data. These evaluation criteria and the caveats specific to each exposure scenario are summarized in Appendix B Table B4. While data from PHED provides the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases.

- *Representativeness of Surrogate Data:* The majority of the application techniques from PHED are typical equipment types expected to be used for chlorpyrifos treatments. However, for scenario 15, a reel-type hose connected to a truck-mounted spray tank monitored for rights-of-way applications is the closest equipment-type available for assessing exposures for citrus and ornamental bark treatments.

- *Use of Biological Monitoring:* The biological monitoring results are reported as arithmetic means as a conservative measure of centrality and because of the small number of replicates, however, using the geometric means (assuming a lognormal dataset) would not effect the risk mitigation measures.

2.1.4 Calculations of Exposure

For passive dosimetry portion of this assessment, potential daily dermal exposure is calculated using the following formula:

$$Daily\ Dermal\ Exposure\left(\frac{mg\ AI}{Day}\right) = Dermal\ Unit\ Exposure\left(\frac{mg\ AI}{lb\ AI}\right) \cdot Max.\ Appl.\ Rate\left(\frac{lb\ AI}{Acre}\right) \cdot Max.\ Area\ Treated\left(\frac{Acres}{Day}\right)$$

Potential daily inhalation exposure is calculated using the following formula:

$$Daily\ Inhal.\ Exposure\left(\frac{mg\ AI}{Day}\right) = Inhal.\ Unit\ Exposure\left(\frac{mg\ AI}{lb\ AI}\right) \cdot Max.\ Appl.\ Rate\left(\frac{lb\ AI}{Acre}\right) \cdot Max.\ Area\ Treated\left(\frac{Acres}{Day}\right)$$

These calculations of potential daily exposure to chlorpyrifos by handlers are used to calculate the absorbed doses and total risk to those handlers.

2.2 Risk From Handler Exposures

Using the potential exposure scenarios identified in the exposure section above, the Agency estimated the potential risk to persons from handler exposures to chlorpyrifos.

Daily Short-term Dermal Dose (mg/kg/day) is calculated as:

$$\frac{\text{Daily Dermal Exposure (mg/day)} * \text{1 (dermal absorption--dermal tox study)}}{\text{Body Weight (kg)}}$$

Daily Intermediate-term Absorbed Dermal Dose (mg/kg/day) is calculated as:

$$\frac{\text{Daily Dermal Exposure (mg/day)} * \text{0.03 (dermal absorption)}}{\text{Body Weight (kg)}}$$

Daily Short- and Intermediate-term Inhalation Dose (mg/kg/day) is calculated as:

$$\frac{\text{Daily Inhalation Exposure (mg/day)} * \text{1 (inhalation absorption)}}{\text{Body Weight (kg)}}$$

Margin of Exposure (MOE) is calculated by dividing the NOAEL by the daily dose.

$$\text{Short and Intermediate Duration Exposure MOE} = \frac{\text{NOAEL (mg/kg/day)}}{\text{Daily Absorbed Dose (mg/kg/day)}}$$

A Total MOE is also calculated because there is a common endpoint (i.e., ChEI). The uncertainty factor of 100 is applied to all routes and exposure durations. Route specific data are available for the dermal and oral routes, and therefore, the following reciprocal MOE calculation is used:

1/((1/Dermal MOE) + (1/Inhalation MOE)

2.2.1 Risk From Handler Exposures

Margins of exposure (MOEs) were calculated for handlers for short-term (one to seven days) and intermediate-term (one week to several months) durations. Appendix A presents the MOE calculations for personal protective equipment (PPE) and engineering controls using the passive dosimetry results from the chemical-specific studies combined with surrogate data from PHED for the agricultural and greenhouse uses of chlorpyrifos. As described in the *Handlers Exposure & Assumptions* section (see Section 2.1.2), the short-term assessment is not provided in HED's traditional table format. The short-term duration is believed to be most representative of private growers and the intermediate-term duration represents commercial applicators who may repeatedly apply chlorpyrifos for 7 or more consecutive days. Appendix A, Tables A1 and A2, present the intermediate-term PPE and engineering control assessments, respectively. Table A3 presents the passive dosimetry scenario descriptions of data confidence for the agricultural and greenhouse uses of chlorpyrifos. Finally, Table A4 presents the intermediate-term assessment using the biological monitoring results from the chemical-specific studies.

The biological monitoring results are available for mixing/loading liquids for groundboom and airblast equipment, mixing/loading wettable powder (WP) for groundboom equipment, groundboom and airblast applicators, mixing/loading/applying (MLA) for tractor-drawn granular spreader, and a low pressure handwand, backpack, and high pressure handwand for uses in greenhouses. Biological monitoring reflects the actual internal dose received by the test subjects, however, these data were not used exclusively to assess the risks because of either the need for additional risk mitigation measures (i.e., closed systems) or an insufficient number of replicates monitored. In fact, the MOEs are less than 100 for all of the intermediate-term biological monitoring scenarios at the level of clothing worn by the test subjects. The biomonitoring results (reported as the arithmetic mean) and the passive dosimetry results (reported as the "best fit" mean) are not directly comparable because of the different measures of centrality and the differences in PPE worn by the test subjects. However, the biological monitoring data support the overall assessment of risk mitigation selected (i.e., engineering controls often required if feasible) for chlorpyrifos.

HED calculated the PPE total MOE for each occupational exposure scenario using the following additional **PPE** assumptions:

- all occupational handlers are wearing footwear (socks plus shoes or boots), foot exposure is not traditionally monitored, and therefore, a 100 percent protection factor is implied;

- occupational mixers and loaders using open mixing techniques are wearing chemical-resistant gloves plus coveralls worn over long-sleeved shirts and long pants;

- occupational applicators who use open cab airblast or tractor-driven application equipment and handlers flagging for aerial applications are wearing chemical-resistant gloves (except flaggers -- no gloves) plus coveralls worn over long-sleeved shirts and long pants; and

- occupational handlers who use low pressure handwands are wearing chemical-resistant gloves plus coveralls worn over long-sleeve shirts and long pants.

- Also, if necessary, a dust/mist mask represented by a 5-fold protection factor is added to mitigate the risks.

If the PPE total MOE was 100 or greater (the NOAEL is based on data from animal studies, and therefore, a 10x is applied for both inter species and intra species variations) for an exposure scenario, then no further calculations were made. If the PPE total MOE remained less than 100 for any occupational exposure scenario, an addition total MOE was calculated based on mandatory use of engineering controls where feasible. Engineering controls are not available for occupational handlers (mixers, loaders, and applicators) who use hand-held application equipment. HED calculated the engineering-control total MOE for each occupational exposure scenario with a PPE total MOE of less than 100, using the following **engineering control** assumptions:

- all occupational handlers are wearing footwear (socks plus shoes or boots), foot exposure is not traditionally monitored, and therefore, a 100 percent protection factor is implied;;

- occupational mixers and loaders handling liquid formulations using a closed system are wearing chemical-resistant gloves plus long-sleeved shirts and long pants;

- occupational mixers and loaders handling wettable powders using a closed system (water-soluble packages) are wearing long-sleeved shirts and long pants, and chemical-resistant gloves; and

- occupational applicators who use aerial, airblast, or tractor-driven application equipment and handlers flagging for aerial applications are located in enclosed cabs or cockpits and are wearing long-sleeved shirts and long pants, and no gloves.

2.2.2 Summary of MOEs

Table 4 summarizes the numeric total MOE values for both the short- and intermediate-term exposure durations. In the majority of cases, it is dermal exposure rather than the inhalation exposure driving the total MOEs. The MOEs are presented for both PPE and engineering controls. PPE represents exposure while wearing coveralls over long pants, long sleeved shirts and chemical resistant gloves, and a dust/mist respirator (5-fold protection factor) while using open mixing/loading systems and open cab tractors. The engineering controls represent exposure while wearing long pants, long sleeved shirts and no gloves (except chemical resistant gloves for closed loading systems) while using closed mixing/loading systems and enclosed cabs/cockpits.

The results of the **short-term** exposure duration indicate that the total MOEs range from 6 to 6,100. A total of 59 MOEs were calculated for the various application rates assessed in each scenario.

Based on the maximum level of protection (e.g., various levels of PPE or engineering controls) two MOEs are estimated to be less than 10; sixteen MOEs are between 10 and 100; and 41 of the MOEs are greater than 100.

The results of the **intermediate-term** exposure duration indicate that the total MOEs range from 1 to 3,100. A total of 59 MOEs were calculated for the various application rates assessed in each scenario. Based on the maximum level of protection (e.g., various levels of PPE or engineering controls) 6 MOEs are estimated to be less than 10; 33 MOEs are between 10 and 100; and 20 of the MOEs are greater than 100.

Table 4
Exposure Variables and MOEs for Agricultural Uses
(Including Non WPS Ornamental Uses) of Chlorpyrifos

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? (a)	Application Rates (lb ai/acre) (b)	Daily Acres Treated (c)	Short-Term Total MOEs		Intermediate-Term Total MOEs	
				PPE	Engineering Controls	PPE	Engineering Controls
Mixer/Loader Exposure							
Mixing/Loading Liquids for Aerial/Chemigation Application (1a)	Yes MRID No. 44739302	1.5 cranberries, corn	350	23	52	7	14
		3.5 citrus (d)	100	34	78	10	21
Mixing/Loading Liquids for Groundboom Application (1b)	Yes MRID No. 42974501	1.5 predominant max / 5.0 tobacco max	80	100 / 30	230 / 69	30 / 9	62 / 19
		2 & 4 Sodfarm (2 includes tobacco/potatoes)	80	75 / 38	170 / 86	23 / 11	46 / 23
		8.0 sodfarm fire ants @ <1 acre/ 10 acres	<1 / 10	1,500 / 150	3,400 / 340	450 / 45	930 / 93
Mixing/Loading Liquids for Airblast Application (1c)	Yes MRID No. 43138102	2.0 predominant max such as Fruits & Nuts / 6.0 citrus	40	150 / 50	340 / 110	45 / 15	93 / 31
Mixing WP for Aerial/Chemigation Application (2a)	No	2.0 predominant max (orchards)	350	NA	23	NA	8
		3.5 citrus (d)	100	NA	46	NA	16
Mixing WP for Groundboom Application (2b)	Yes MRID No. 42974501	1.0 predominant max (brassica)	80	NA	200	NA	72
		4.0 soil treatment ornamentals outdoors	10	NA	400	NA	140
		1.3 & 3.0 Sodfarm	80	NA	150 / 67	NA	55 / 24
		8.0 sodfarm fire ants (harvest only)	<1 / 10	NA	2,000 / 200	NA	720 / 72
Mixing WP for Airblast Application (2c)	No	2.0 predominant max / 6.0 citrus	40	NA	200 / 67	NA	72 / 24
Loading Granulars for Aerial Application (3a)	No	1.95 maximum aerial rate	350	25	270	15	200
Loading Granulars for Ground Application (3b)	Yes MRID No. 44483501 (3b and 8)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80	210 / 110 / 71	2300 / 1200 / 780	130 / 64 / 43	1700 / 860 / 570

Table 4
Exposure Variables and MOEs for Agricultural Uses
(Including Non WPS Ornamental Uses) of Chlorpyrifos

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? (a)	Application Rates (lb ai/acre) (b)	Daily Acres Treated (c)	Short-Term Total MOEs		Intermediate-Term Total MOEs	
				PPE	Engineering Controls	PPE	Engineering Controls
Applicator Exposure							
Aerial (Spray) -- Enclosed Cockpit (4a)	No	2.0 orchards	350	NE	60	NE	17
		3.5 citrus (d)	100	NE	120	NE	35
Aerial (Granulars) -- Enclosed Cockpit (4b)	No	1.95	350	NE	8	NE	7
Groundboom Tractor (5)	Yes MRID No. 42974501	1.5 predominant max / 5.0 tobacco max	80	NE	310 / 120	NE	110 / 32
		1.3 /2 / 3 / 4 Sodfarms	80	NE	470 / 310 / 200 / 150	NE	120 / 81 / 54 / 40
		8.0 sodfarm fire ants	<1 / 10	NE	6,100 / 610	NE	1,600 / 160
Airblast Applicator (6)	Yes MRID No. 43138102	2.0 predominant max / 6.0 citrus	40	NE	140 / 35	NE	37 / 12
Tractor-Drawn Granular Spreader (7)	Yes MRID No. 44483501 (3b and 8)	1.0 typical corn / 2.0 max corn / 3.0 maximum ground rate (tobacco)	80	270 / 140 / 90	330 / 170 / 110	130 / 66 / 44	200 / 100 / 68
Seed Treatment (8)	No	No Data	No Data	No Data	No Data	No Data	No Data
Dip Application (Preplant Peaches) (9)	No	No Data	No Data	No Data	No Data	No Data	No Data
Flagger Exposure							
Spray Applications (10)	No	2.0 predominant max	350	37	880	9	340
		3.5 citrus (d)	100	74	1800	19	690
Granular Applications (11)	No	1.95	350	170	2500	54	1200

Table 4
Exposure Variables and MOEs for Agricultural Uses
(Including Non WPS Ornamental Uses) of Chlorpyrifos

Exposure Scenario (Scenario #)	Are Biological Monitoring Data Available? (a)	Application Rates (lb ai/acre) (b)	Daily Acres Treated (c)	Short-Term Total MOEs		Intermediate-Term Total MOEs	
				PPE	Engineering Controls	PPE	Engineering Controls
Mixer/Loader/Applicator Exposure							
Backpack Sprayer (12)	Yes MRID No. 43027901	0.0417 lb ai/gal predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day	110 / 58 / 150	NE	25 / 13 / 35	Not Feasible
		3.5 citrus bark	1 A/day	53	NE	12	Not Feasible
		0.039 lb ai/gal / 750 ft2	1000 ft2	3500	Not Feasible	810	Not Feasible
Low Pressure Handwand (13)	Yes MRID No. 43027901	0.0417 predominant max / 0.08 lb ai/gal bark beetle treatment / 0.03 lb ai/gal stump treatment	40 gal/day	310 / 160 / 440	NE	98 / 51 / 140	Not Feasible
		3.5 citrus bark	1 A/day	150	NE	47	Not Feasible
		0.039 lb ai/gal / 750 ft2 animal prem.	1000 ft2	10000	Not Feasible	3,100	Not Feasible
High Pressure Handwand (greenhouse uses) (14)	Yes MRID No. 43027901	Min. 0.0033 lb ai/gal	1000 gal/day	38	NE	12	Not Feasible
		Max. 0.0066 lb ai/gal		19	NE	6	Not Feasible
Hydraulic Hand-held Sprayer for Bark / Pine Seedling Treatment (15)	No	3.5 citrus bark	10	28	NE	3	Not Feasible
		0.08 lb ai/gal bark beetle treatment / 0.16 lb ai/ gal pine seedling treatment /	1,000	12 / 6	Not Feasible	3 / 1	Not Feasible
		0.039 lb ai/gal / 750 ft2 animal prem	10000 ft2	1900	Not Feasible	420	Not Feasible
Dry Bulk Fertilizer Impregnation	No	1.0 lb ai / 200 lb fertilizer / acre	No Data	No Data	No Data	No Data	No Data

NE = Not evaluated

(a) Biological monitoring data are available from several chemical-specific studies. Although biological monitoring scenarios are available for some of the scenarios as indicated in this table, passive dosimetry data are presented for comparison because insufficient replicates and/or additional risk mitigation measures were necessary.

(b) Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-38, -221, -245, -34; -79, -72, -

166, -220, 34704-66 (Clean Crop Chlorpyrifos 4E -- sodfarm fire ant rate), 499-367 (499-367 is the only greenhouse label identified), and 10350-22 for animal premise treatments. **"Predominant max"** in this table refers to the most **frequently identified maximum** application rate found on the labels for the specific formulation and equipment type. Typical rates are also included to characterize the chlorpyrifos uses. Not all application rates are included for all crops, instead, a cross-section of rates are used to represent the uses of chlorpyrifos.

(c) Daily acres treated are based on HED's estimates of acreage (or gallonage) that would be reasonably expected to be treated in a single day for each exposure scenario of concern. The sodfarm fire ant rate is restricted on the label for harvest only, therefore, this rate is limited to the amount of sod that may be harvested in a reasonable time frame. Therefore, using the limited data available, approximately 10 acres treated per day are assumed to be the upper range along with the median value of <1 acre.

(d) The application rates on the Lorsban 4E (EPA Reg. No. 62719-220) and 50W (EPA Reg. No. 62719-39 discontinued as of 1995 and sold as -221) labels indicate that for citrus at the 6.0 lb ai/A rate it is necessary to use 100 to 2,400 gallons per acre dilute spray. Therefore, this rate is not expected to be feasible for an aerial applicator. The label language should be clarified so that the 6.0 lb ai/A rate is for ground only. Additionally, citrus orchards are believed to be relatively small plots and 100 acres per day is assumed in the assessment for aerial applications.

2.2.3 Insufficient Data

The Agency has insufficient exposure data to provide an assessment of seed treatment applications, dip applications, and dry bulk fertilizer. In addition to exposure data, the types of seed treatment practices for chlorpyrifos need to be submitted (e.g., are the treatments done on site?). DAS submitted additional information on dip applications other than preplant peaches which include dipping of balled and burlapped or containerized stock for fire ant quarantine regulations and for Japanese beetle control for US/Canada transport of nursery stock. The current mixer/loader surrogate data do not appear to be representative for dip treatments in agricultural or nursery/greenhouse settings. Additionally,chemical-specific and/or accurate surrogate exposure data and use information are needed for dry bulk fertilizer (impregnation and application). Nonetheless, this scenario is of concern because the MOEs for closed loading of liquids for aerial and groundboom applications are less than 100 and a similar amount of chlorpyrifos is assumed to be handled. The applicator exposure associated with dry bulk fertilizer applications to citrus groves is also of concern as indicated by the MOEs (less than 100) for applying granulars with a tractor-drawn spreader. According to the Lorsban 4E label, chlorpyrifos is applied at a rate of 1 lb ai per 200 pounds of fertilizer per acre and that the mixture must be applied immediately, not stored. More information is needed to properly estimate the exposure/risk. Information needed includes how many acres per day can be treated?; can the dry bulk fertilizer be prepared at a commercial facility, if so, what is the process and how much active ingredient would be handled in a day?; and what types of surrogate data are available for this scenario?

Finally, there are possible dermal and inhalation exposures to handlers applying eartags to livestock. No chemical-specific or surrogate data are available to assess handler exposure from this specialized use pattern. The Agency estimates that handler dermal and inhalation exposure would be minimal, since the product is impregnated in relatively small quantities into the device as purchased. Worse-case estimate would assume that one percent of the active ingredient impregnated into each

eartag would be available on the surface to cause exposure to the applicator's hands. Even with a vapor pressure of 1.87E-5 mmHg, the inhalation exposure should be minimal since the product is applied outdoors, relatively small amounts of active ingredient are handled per day, and the product is impregnated into the eartag. EPA estimates that the only dermal exposure of possible significance might be to the hands. Dermal exposures other than to the hands should be rare. Consequently, in lieu of exposure data upon which to assess risk, EPA will require handlers to wear chemical-resistant gloves in addition to baseline attire while handling/applying the impregnated eartags.

3.0 POSTAPPLICATION EXPOSURES

EPA has determined that there is potential exposure to persons entering treated sites (e.g., scouts and harvesters) after application is complete. Postapplication exposure data were required during the chlorpyrifos DCI of the reregistration process, since, at that time, one or more toxicological criteria had been triggered for chlorpyrifos. Although several studies have been submitted, it was still necessary to use HED's standard values for transfer coefficients and crop-specific residues as substitutes to represent other crops. Activity-specific transfer coefficients are currently being developed by the Agricultural Reentry Task Force (ARTF). Once ARTF submits the activity-specific transfer coefficients, these values will be used to replace the standard values provided below.

3.1 Postapplication Exposures & Assumptions

3.1.1 Submitted Studies

The following are the postapplication data submissions used in the risk assessment:

- **MRID No. - 429745-01.** Shurdut, B.A. et al. 1993. Lorsban 4E and 50W insecticides: assessment of chlorpyrifos exposures to applicators, mixer/loaders and re-entry personnel during and following application to low crops.

  Passive dosimetry (dermal and inhalation) and biological monitoring samples (urine analysis) were collected for 10 replicates each of scout reentry into cauliflower and tomato sites. The dermal reentry exposure data were monitored concurrently with the dislodgeable foliar residue (DFR) data approximately 24 hours after chlorpyrifos treatment. DFR data were collected on 0, 1, 2, 3, 5, 7, 14, 21, and 30 days after treatment (DAT). The post-application portion of this study used the Lorsban 50W formulation. The Lorsban 50W was applied by groundboom to cauliflower in Arizona and tomatoes in Florida at 1 lb ai/acre. To summarize, this study meets the acceptability criteria outlined in Subdivision K of the Pesticide Assessment Guidelines except that only five replicates per activity (per crop) were monitored and that the Lorsban 4E label allows for a maximum rate of 2 lb ai/acre. The quality control/quality assurance aspects of the study were adequate.

- **MRID No. - 430627-01.** Honeycutt, R.C. and DeGeare M.A. 1994. Worker reentry exposure to Chlorpyrifos in citrus treated with Lorsban 4E Insecticide.

  A single application of Lorsban 4E was applied using an airblast sprayer at the maximum application rate (6 lb ai/acre) to citrus groves (lemons and oranges) at three sites in CA. The sites are identified as #2 (oranges), #5 (oranges), and #6 (lemons). Five replicates of orange (site #2) harvesting (workers identified in the study as "pickers") were monitored 43 days after treatment (DAT). Monitoring of the reentry workers was intended to be 35 DAT (label PHI), however, the oranges were not ripe. In addition, 10 replicates of

pruners were monitored, 48 hours after treatment. The table below summarizes the site specific information.

Summary of Site Specific Information.

Site Number	Crop	Activity Monitored	DAT Activity Monitored	Location
2	Oranges	Pickers (n=5)	43	Tulare County, CA
5	Oranges	Pruners (n=5)	2	Tulare County, CA
6	Lemons	Pruners (n=5)	2	Kern County, CA

The study also monitored dislodgeable foliar residues (DFR) concurrently with the human exposure samples. Additional DFRs samples were collected at 0, 1, 2, 4, 5, 7, 14, 21, 35, 40, and 43 DAT at the various sites. Dosimetry and biological monitoring were conducted to determine potential exposure as well as total absorbed dose. Critical items pertaining to the acceptability of the study identified include (1) only five replicates for pickers were monitored, not the required 10 replicates, and (2) the storage stability for the Chromosorb tubes and urine were not presented in the data submission but instead the registrant indicated their stability. Uncertainty exists in determining the transfer coefficient for the picker at 43 DAT because only five replicates of human exposure were monitored and the DFR data on 43 DAT were all nondetects. The selection of 43 DAT for determining the transfer coefficient when the DFRs are all nondetected is a perplexing problem because samples to monitor citrus harvesting cannot be collected any earlier than 35 DAT (i.e., 35 day PHI). Because a 35 day PHI exists, HED views the use of the estimated transfer coefficient for determining a citrus harvesting REI the best available data. Finally, chlorpyrifos has been successfully monitored in several other data submissions using Chromosorb tubes and urine. Therefore, the lack of storage stability data in this submission will not affect the use of the monitoring data.

- **MRID No. - 447481-01.** Dissipation of Dislodgeable Foliar Residues of Chlorpyrifos from Treated Orchard Trees.

  This study is currently under review by HED. The preliminary DFR results are reported below in Section 3.1.2 and are used in the postapplication assessment.

- **MRID 447481-02:** Gardner, R.C. and Blakeslee, B.A. 1999. Dissipation of Dislodgeable Foliar Residues of Chlorpyrifos from Treated Cotton, Sugar Beet and Sweet Corn Row Crops.

  Two applications of Lorsban 4E, Lock-On and Lorsban 15G were applied 5 days apart to test fields. Test fields were located in CA, TX, MS, OR, MN and IL for Lorsban 4E, CA, AZ and TX for Lock-On and CA, AZ and TX for Lorsban 15G. Applications of products were made at maximum application rate/crop (lb ai/A), for cotton and sugar beets. Lorsban 4E sweet corn applications were 1 lb ai/A which is below the 1.5 lb ai/A maximum rate. Applications of Lock-On were made at the maximum label rates/crop of 0.5 lb ai/A. Lorsban 15G applications to sweet corn was made at the maximum label rate of 1 lb ai/acre. Liquid applications were made using typical tractor mounted boom sprayers and the granular was applied with a motor- or

ground-driven dispensing impeller.

This study was conducted June through August, with the plants characterized as healthy and in vigorous growing condition. From the weather data (MRID 448264-01) it appears that no significant rainfall fell during the early collection period and irrigation was in-furrow. This would not contribute to loss of chlorpyrifos on the leaves tested. The data from leaf punches after the second treatment were used to characterize concentration of chlorpyrifos on treated crops and the rate of dissipation. The LOD and LOQ were reported as 0.001 μg/cm^2 and 0.003 μg/cm^2 respectively.

The registrant has supplied the Agency with predicted concentration values for chlorpyrifos from the non-linear Minitab regression used in the study. When examining the registrant's predicted values against the raw data collected, the predicted concentrations from 1DAT2 through 7DAT2 were significantly under predicted.

Due to the rapid dissipation of chlorpyrifos in the test fields from 0DAT2 to 1DAT2, HED used JUMP software to calculate a regression curve from DAT 1 to DAT 7. The average of the data collected from 0DAT2 will be used to calculate the exposure on the day of treatment. The dissipation of chlorpyrifos from 1DAT2 to 7DAT2 on each field was fit to a regression using the following formula:

$$C_t = A(e^{-kt})$$

Where: C_t = Concentration of Residue at time t,
A = Constant (Varies with site and formulation),
e = the base of natural logarithms,
k = slope of the curve,
t = postapplication interval from DAT 1 to DAT 7 (1-7 days).

Results from the HED regression for each site are presented in study review and summarized below in this chapter. The Oregon sugar beet data were inconsistent (average 2DAT2 and 4DAT2 values were higher than average 1DAT2) and could not be well fit by a single curve. Residue levels collected from the granular applications showed no dissipation pattern and were largely non-detects; therefore no calculations were made for the regression of Lorsban 15G.

In addition to these reentry studies, two additional registrant-generated risk assessments were submitted using the collected data. The risk assessments are summarized below. As noted below, the results of these assessments are not used in the Agency's risk assessment.

- **MRID No. - 430627-02.** Chlorpyrifos: an exposure assessment of reentry workers following application in citrus crops.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 430627-01. In the original exposure monitoring study cited in the registrant-generated

assessment, Lorsban 4E was monitored for workers harvesting and pruning in citrus groves. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposure as well as total absorbed dose. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results, as reported in the registrant-generated assessment, based on using the "t-dist" function in Microsoft Excel 4.0, shows that the probability of a harvester reaching the NOEL of 0.03 mg/kg/day is about 2 in 100,000 and the worst case for pruners is 2 in 10,000 for the NOEL of 0.1 mg/kg/day. However, the Agency does not regulate at the NOAEL but rather beyond the NOAEL based on uncertainty factors (e.g., 10x for intra-species variation). Therefore, the Agency used the data to perform its own risk assessment.

- **MRID No. - 429944-01.** Chlorpyrifos: an exposure and risk assessment of workers associated with mixing/loading, application and reentry following ground boom application to low crops.

  This study is a risk assessment generated by the registrant based on the data submitted in MRID No. 429745-01. In the original exposure monitoring study cited in the registrant-generated assessment, LORSBAN 4E and LORSBAN 50W were monitored during mixing/loading, groundboom application, and scouting. Passive dosimetry and biological monitoring were conducted to determine potential inhalation and dermal exposure as well as total absorbed dose. Only the biological monitoring data were used in the registrant-generated assessment. The registrant-generated assessment is based on plasma cholinesterase activity from an oral human study using NOELs of 0.1 mg/kg/day for single exposure events and 0.03 mg/kg/day for multiple exposure events. The results, as reported in the registrant-generated assessment, based on a Student t-test statistical analysis, show that there is a finite probability (0.6%) for an individual who repeatedly scouts in LORSBAN treated fields to exceed the "NOEL" for multiple exposures to chlorpyrifos. However, the Agency does not regulate at the NOAEL but rather beyond the NOAEL based on uncertainty factors (e.g., 10x for intra-species variation). Therefore, the Agency used the data to perform its own risk assessment.

3.1.2 Summary of Dislodgeable Foliar Residues

The postapplication monitoring studies submitted provide DFR data for cauliflower, tomatoes, cotton, sugar beets, corn, citrus, almonds, apples, and pecans. The DFR data in these studies were collected at three sites for each of these crops. Because of the absence of additional DFR data for the various other crops treated with chlorpyrifos, the cotton, sugar beets, and corn DFR data are used as surrogate residue values for other crops. The DFR data from these crops were used as surrogates to calculate potential exposure resulting from harvesting activities for field crops grouped as **"low"**, **"medium"**, and **"high"** potential for dermal contact. Uncertainties are introduced into the assessment when crop-specific residues are used to estimate residues from other types of crops, however, it is believed to be more realistic than assuming a default initial residue value based on the application rate and an assumed dissipation rate per day. The cauliflower, tomato, citrus, almond, apple, and pecan DFR data are used solely for assessing reentry exposures to those specific crops. All of the DFR data are

presented in the tables below.

Sugar Beets, Cotton, Corn DFR Data:

The data sets for sugar beets, cotton, and corn (MRID 447481-02) are used to represent field crops with a "low", "medium", and "high" potential for dermal contact, respectively. The data for the three crops listed were monitored at an application rate of 1 lb ai/acre. The crops in the surrogate assessment have application rates of 1 to 2 lb ai/acre and these DFR data are normalized where appropriate. The raw and predicted DFR data at 1 lb ai/acre are provided in the table below.

Summary of Cotton, Sugar Beets, and Corn Dissipation Data Based On a Non Linear Regression.

Crop	Non Linear Regression, Predicted Values									
	DFR (μg/cm^2) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
Cotton (LockOn)	0.608	0.0227 (0.018)	0.00898 (0.037)	0.00398	0.00195 (0.003)	0.00102	0.000566	0.000324 (0.0027)	0.86	0.81 to 0.96
Cotton (4E)	1.25	0.0308 (0.036)	0.0162 (0.013)	0.00875	0.00483 (0.0083)	0.00271	0.00153	0.000872 (0.002)	0.95	0.88 to 0.95
Beets	0.600	0.0334 (0.0327)	0.0211 (0.022)	0.0135	0.00872 (0.0083)	0.00571	0.00382	0.00261 (0.0037)	2.9	0.05 to 0.98
Corn	1.10	0.0196 (0.0193)	0.0107 (0.0113)	0.00594	0.00334 (0.0030)	0.00189	0.00108	0.000623 (0.0010)	1.1	0.83 to 0.94

Cauliflower DFR Data:

The cauliflower data (MRID 429745-01) represent DFR levels obtained at an application rate of 1 lb ai/acre using the Lorsban 50W. The maximum labeled rate for cauliflower is 1 lb ai/A on the Lorsban 50W (EPA Reg. No. 62719-221) and 2.0 lb ai/A for the Lorsban 4E (EPA Reg. No. 62719-220 dated 2/1/99). The predicted DFR levels (μg/cm^2), based on the slope and intercept, are normalized (i.e., DFR data multiplied by 2) to account for a potential increase in residues when chlorpyrifos is applied at its maximum application rate of 2 lb ai/acre (Lorsban 4E - EPA Reg. No. 62719-220). The coefficient of determination (R^2) and dissipation rates for the three cauliflower sites (i.e., sites identified in the study as ABC, DEF, and GHI) are similar. Therefore, all of the data for the three sites were combined for the linear regression.

Cauliflower Dissipation Data for Sites ABC, DEF, and GHI Combined and Normalized to the Maximum Application Rate.

Site	DFR (μg/cm^2) -- Predicted Values Based On Log Transformed Data (Values in Parentheses Are Normalized Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
All Sites	1.278 (1.438)	0.995 (1.174)	0.774 (0.732)	0.603 (0.650)	0.469	0.365 (0.376)	0.284	0.221 (0.216)	2.8	0.94

Sites ABC, DEF, and GHI (Yuma, AZ): 0, 1, 2, 3, 5, 7, 14, 21, and 35 DAT, the last two intervals all samples were nondetect and only up to and including 21 DAT are used in the regression; actual monitored data multiplied by 2 to estimate the maximum label application rate.

Tomato DFR Data:

The tomato data (MRID 429745-01) represent DFR levels obtained at an application rate of 1 lb ai/acre using the Lorsban 50W. The R^2 and half-life data for the residues monitored at the three tomato sites (i.e., sites identified in the study as JKL, MNO, and PQR) were compared. Residues monitored at site JKL were selected for this assessment. The raw data from sites MNO and PQR are erratic and were not of use for the assessment. Both the predicted residue values (based on the log transformed data) and the raw data (also normalized by application rate) are provided in the table below. The initial variation between the predicted values and the raw data do not impact the assessment because the reentry interval (see Risk Section for details) occurs when the two dissipation curves reach a similar residue value.

Tomato Dissipation Data for Site JKL Normalized to the Maximum Application Rate.

Site	DFR (μg/cm^2) -- Predicted Values Based On Log Transformed Data (Values in Parentheses Are Normalized Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
JKL	0.480 (4.44)	0.391 (0.698)	0.319 (0.428)	0.260 (0.150)	0.212	0.172 (0.036)	0.140	0.114 (0.064)	3.4	0.75

Site JKL (Florida): 0, 1, 2, 3, 5, 7, 14, 21, and 30 DAT; actual monitored data multiplied by 2 to estimate the maximum label application rate.

Citrus DFR Data:

The citrus data (MRID 430627-01) represent DFR levels obtained at the maximum application rate for citrus of 6 lb ai/acre. Therefore, it was not necessary to normalize the predicted DFR levels (μg/cm^2). The summary of the dissipation data are listed in the table below. The data indicate that the chlorpyrifos dissipation in citrus is biphasic, and therefore, the 0 to 7 DAT sampling intervals were used in determining the predicted residues.

Summary of Citrus and Lemon Dissipation Data Based On Only 0 to 7 DAT Sampling Intervals.

Site	Biphasic: 0 to 7 DAT Sampling Intervals, Predicted Values -- Based On Log Transformed Data									
	DFR (μg/cm^2) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
2	0.99 (1.5)	0.63 (0.21)	0.40	0.25	0.16 (0.096)	0.10 (0.079)	0.064	0.041 (0.074)	1.5	0.83
5	1.25 (1.8)	0.55 (0.55)	0.24 (0.16)	0.10	0.046	0.020	0.0087	0.0038 (0.0076)	0.84	0.92
6	0.76 (1.5)	0.40 (0.37)	0.21 (0.082)	0.11	0.060	0.032	0.017	0.0090 (0.013)	1.1	0.84
All Sites	0.95 (1.6)	0.52 (0.48)	0.29 (0.12)	0.16	0.086 (0.096)	0.047 (0.079)	0.026	0.014 (0.032)	1.2	0.78

a Site 2 (Oranges Tulare County, CA): 0, 1, 4, 5, 7, 14, 21, 35, and 43 DAT, at 1 DAT 4 of the 6 samples were nondetect and are excluded;
Site 5 (Oranges Tulare County, CA): 0, 1, 2, 7, 14, and 40 DAT;
Site 6 (Lemons Kern County, CA): 0, 1, 2, 7, 14, and 35 DAT; and
All Sites: 0, 1, 2, 4, 5, 7, 14, 21, 35, 40, and 43 DAT.

Almond, Apple, and Pecan DFR Data:

The almond, apple, and pecan DFR study is currently under review. The DFR data were analyzed and the results are presented in the table below.

Summary of Almond, Apple, and Pecan Dissipation Data Based On Only 0 to 7 DAT Sampling Intervals.

Crop	Biphasic: 0 to 7 DAT Sampling Intervals, Predicted Values -- Based On Log Transformed Data									
	DFR (μg/cm^2) -- (Values in Parentheses Are Field Measured Values)								Half-life (days)	R^2
	0 DAT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT		
Almond	0.834 (1.76)	0.458 (0.48)	0.251 (0.27)	0.138	0.0756 (0.062)	0.0415	0.0228	0.0125 (0.026)	1.2	0.72
Apple	0.677 (1.47)	0.307 (0.44)	0.139 (0.18)	0.0631	0.0286 (0.018)	0.0130	0.0059	0.0027 (0.0046)	0.88	0.79
Pecan	0.0837 (0.27)	0.0488 (0.043)	0.0284 (0.019)	0.0166	0.0096 (0.010)	0.0056	0.0033	0.0019 (0.0043)	1.3	0.67

3.1.3 Summary of Transfer Coefficients

Transfer coefficients (Tc) are used to relate the DFR values to activity patterns (e.g., harvesting) to estimate potential human exposure. Harvesting activities are assessed in this RED using both chemical- and activity-specific transfer coefficients along with surrogate harvesting transfer coefficients to estimate potential exposure levels for all crops to determine the reentry intervals (REIs). Chemical- and activity-specific transfer coefficients developed to support chlorpyrifos include: (1) citrus harvesting, (2) citrus tree prunning, (3) cauliflower scouting, and (4) tomato scouting. The dermal exposure levels during the activity of **harvesting citrus** were monitored concurrently with the DFR levels in MRID 430627-01. The transfer coefficient for harvesting citrus ranged from 6,650 to 7,494 cm^2/hr and averaged 6,891 cm^2/hr. The transfer coefficient for **pruning citrus trees** during rainy conditions ranged from 2,337 to 3,929 cm^2/hr and averaged 3,213 cm^2/hr; and 1,121 to 1,673 cm^2/hr (average 1,371 cm^2/hr) in dry conditions. The dermal exposure levels during the activity of **scouting in the cauliflower and tomato** fields were monitored concurrently with the DFR levels in MRID 429745-01. The transfer coefficients for scouting are 738 cm^2/hr for cauliflower and 677 cm^2/hr for tomatoes.

Since chemical- and activity-specific transfer coefficients are not available for all crops, it is necessary to group the exposure potential resulting from postapplication activities. These three groupings include **"low"**, **"medium"**, and **"high"** potential for dermal contact. HED's agricultural default transfer coefficients for field crops with a "low", "medium", and "high" potential for dermal contact are 2,500, 4,000, and 10,000 cm^2/hr, respectively. These transfer coefficients are believed to represent a conservative reliable estimate of potential exposures while harvesting. **These transfer coefficient defaults are in use until the Agriculture Reentry Task Force (ARTF) provides activity-specific data.** Table 5 presents a matrix for potential activity-specific contact rates and crop groupings used in the postapplication assessment.

Table 5. Postapplication Potential Dermal Contact Rate and Crop Grouping Matrix[a]

Potential for Dermal Contact	Transfer Coefficient (cm^2/hr)[b]	Activities	Application Rate (lb ai/A)	Crops
Low	2,500	Harvest	1 (Reg. No. 62719-220)	Alfalfa, asparagus, small grains (wheat, sorghum, milo), soybeans

			2 (Reg. No. 62719-220)	Cole crops, mint
		Sort/Pack	1 (Reg. No. 62719-220)	Sugar beets
			2 (Reg. No. 62719-220)	Radishes (up to 2.75 lb ai/A), rutabagas (up to 2.25 lb ai/A)
Medium	4,000	Harvest, stake/tie, scout, irrigate	1 (Reg. No. 62719-220)	Cranberries, strawberries
		Irrigate	1 (Reg. No. 62719-220)	Christmas trees
		Late season scouting	1 (Reg. No. 62719-220)	Cotton
High	10,000	Hand Harvest [c]	1 (Reg. No. 62719-220)	Sunflowers (up to 1.5 lb ai/A), corn (up to 1.5 lb ai/A as a foliar treatment)
			2 (Reg. No. 62719-220)	Sweet potatoes
		Cut/harvest, prune, transplant, ball/burlap	1 (Reg. No. 62719-220)	Christmas trees

[a] Citrus foliar treatments are assessed separately using the chemical-specific data in MRID 430627-01; Tree Nuts & Fruits are assessed separately using the citrus data (normalized to 2 lb ai/A) as a surrogate.
[b] Standard values for transfer coefficients are from HED Exposure Science Advisory Council (SAC) Policy #3 dated May 7, 1998.

Finally, grape harvesting activities were not analyzed separately because the only use on the labels is for a grape vine based treatment (i.e., pouring solution at the base of the grape vine), no foliar treatments were identified. In addition to the foliar chlorpyrifos treatments, there are many soil incorporated treatments. These soil incorporated treatments, depending upon the postapplication activities, often result in less postapplication exposure than the foliar treatments. Examples of soil incorporated uses include treatments for onions, peanuts @ 2 lb ai/acre, sweet potatoes @ 2 lb ai/acre, corn @ 3 lb ai/acre, and tobacco @ 3 lb ai/acre (5 lb ai/acre in NC, SC, and VA). Even though these treatments are soil incorporated, potential exposure exists for transplanting tobacco (label allows transplanting within 24 hours after treatment) and onion sets or other activities that involve disturbing the soil such as hoeing. At this time, there are insufficient exposure and soil residue data to assess the potential risk from soil incorporated uses of chlorpyrifos.

3.1.4 Summary of Uncertainties

The postapplication exposure assessment encompasses all of the major uses of chlorpyrifos throughout the country. It is difficult to assess all of the "typical" agricultural uses for chlorpyrifos (i.e.,

actual or predominant application rates -- "predominant" being defined as the most frequently found rates on labels). DAS recently submitted a use survey (i.e., Mar Quest research study) to assist the Agency in determining how chlorpyrifos is used in the field. However, at the time that this chapter was developed, the Mar Quest study had just been received and its scope has not been reviewed. Once reviewed, the Agency will incorporate the appropriate information from this survey to better characterize chlorpyrifos risks for the Agency's risk managers. In the mean time, an assessment has been developed

which is believed to be realistic based on allowable uses on the labels and yet provides a reasonable certainty that the exposures are not underestimated. Some of the specific DAS requests for clarification and interpretation of product labels and application techniques are included. The assumptions and uncertainties are identified below to be used in risk management decisions:

- *Crop Specific Residues:* A multitude of crops are treated with chlorpyrifos and crop-specific residue data are not available for all situations. Therefore, the use of the available data to "simulate" residues on other crops introduces uncertainties in the setting of reentry intervals. It is reasonable to believe that the residues monitored in the available studies approximate the residues on other crops, but the extent that these residues might be an under- or overestimate is unknown. The Agency is currently analyzing the DFR data submitted for cotton, corn, and sugar beets (MRID 447481-02). The DFR results from these crops may alter the surrogate assessment for determining REIs.

- *Normalization of Residues:* The residues in MRID 429745-01 were not monitored at the maximum application rate specified on chlorpyrifos labels (Lorsban 4E - EPA Reg. No. 62719-220). Therefore, the residues were normalized from the rate used in the study (1 lb ai/acre) to reflect the maximum application rate of 2 lb ai/acre. Normalizing the residues to the maximum application rate is a standard practice used by HED so as not to underestimate the residues. Note: There are a couple of crops within this group that can be applied above the 2 lb ai/A rate (e.g., radishes 2.75 lb ai/A).

- *Site Selection:* Individual sites were selected based on the best available data. The residues for the cauliflower data were nearly identical so all sites were combined. Two of the tomato sites were not selected because of the difficulties discussed above. The citrus data were combined for all sites and only the first seven days of dissipation are used in the assessment because the data are biphasic (DFR data for pecans, almonds, and apples were also biphasic and only the first seven days were used to determine the dissipation curve).

- *Transfer Coefficients:* The transfer coefficients selected are based on the activities monitored in the submitted studies and on HED's policy for surrogate values until the results of the Agricultural Reentry Task Force (ARTF) are available. These values are believed to be reasonable estimates that would not underestimate the risks.

- *Exposure Duration:* The amount of time (e.g., days) that a worker would be involved in postapplication activities is not available. Therefore, both short-term and intermediate-term exposure durations are provided and the intermediate-term duration is believed to be most representative for the postapplication exposures. Furthermore, the REIs are calculated at the residue level predicted on a specific day after treatment; subsequent declining residue levels (i.e., average residues under the dissipation curve) are not incorporated into the assessment because of the lack of exposure duration data (including the fact that harvesters may travel to multiple fields). Note: Scouts are assumed to be exposed 8 hours per day, which may be an overestimation.

- *Timing of Application:* Many of the chlorpyrifos treatments (e.g., citrus and tree fruits) are tree

trunk/bark applications in the dormant to early season. Nonetheless, REIs are established for harvesting to assess the potential exposures. Scouting and pruning activities are assessed separately.

3.2 Risk From Postapplication Exposures

3.2.1 Summary of REIs

Crop Groupings

The calculated daily dermal absorbed dose and MOEs based on the DFR data and transfer coefficients discussed in Table 5 in the *Postapplication Exposures & Assumptions* section above, are presented in Appendix B, Tables B1 through B4. These tables present the short- and intermediate-term surrogate assessments that are designed to encompass the majority of harvesting scenarios for chlorpyrifos treated crops at the application rates of 1 and 2 lb ai/acre. For the short-term assessments, the dermal absorption of chlorpyrifos is not used in the estimate of absorbed dermal dose because the toxicological endpoint is from a 21-day dermal study. The intermediate-term assessment uses a 3 percent dermal absorption because the toxicological endpoint is from an oral study.

The DFR data used in the surrogate assessments for field crops with a "low", "medium", and "high" potential for dermal contact activities are from MRID 447481-02 (specifically from sugar beets, cotton, and corn). These DFR data were generated at an application rate of 1 lb ai/acre. The maximum label rates representing the crops that fall into these three categories are 1 and 2 lb ai/acre on the Lorsban 4E and 50W labels. Therefore, it was necessary to provide REIs at the 1 lb ai/acre rate and the normalized rate of 2 lb ai/acre to reflect the residues at the higher chlorpyrifos application rate. HED assumed a linear relationship between DFR and the application rate in normalizing the residues. A summary of the field crops with a "low", "medium", and "high" potential for dermal contact activities and the associated crops are presented in Table 5 of the *Postapplication Exposures & Assumptions* section. Note: Any crops not specifically mentioned and are within the scope of the surrogate assessment will need to be placed into the matrix at a later date.

Table 6 presents the summary of the reentry intervals (REIs) for the "low", "medium", and "high" potential dermal contact rates as presented in detail in Appendix B. The REI is set at the day after treatment (DAT) that the MOE is 100 or greater. Duration of exposure activities (i.e., days engaged in sort/pack, irrigation, harvesting, etc.) are presumed to be of an intermediate-term duration. Nonetheless, for a complete assessment, Table 6 presents both the short-term (1 to 7 days) and intermediate-term (7 to 90 days) assessment of REIs.

Table 6. Summary of the Short- and Intermediate-Term REIs for the Contact Rates and Crop Grouping Matrix.

Potential for Dermal Contact	Short-Term REIs (days)		Intermediate-Term REIs (days)	
	1 lb ai/A	2 lb ai/A	1 lb ai/A	2 lb ai/A
LOW	1	1	3	3

MEDIUM	1	No crops	2	No crops
HIGH	1	2	3	4

No crops were identified on the labels at the 2 lb ai/acre rate in the "medium" grouping.

Postapplication risks are mitigated for crop advisors/scouts using entry restrictions, not restricted-entry intervals. Since under the Worker Protection Standard for Agricultural Pesticides -- 40 CFR Part 170, crop advisors/scouts are defined as handlers, the Agency can permit such persons to enter treated areas to perform scouting tasks, provided they are using required personal protective equipment. Additionally, the crop advisor exemption allows certified or licensed crop advisors to choose appropriate protection to be utilized while performing crop advising tasks in treated area for themselves and for their employees. However, the WPS exemption does not exempt crop advisors from regulation under FIFRA-Sections 3, 6, and 12, and Title 40 CFR Part 156.204(b)-Labeling in regard to risk concerns identified through reregistration or other EPA risk assessment /data evaluations processes.

The biological monitoring results of the cauliflower and tomato study (MRID No. 429745-01) indicate that the **scouts** require an entry restriction for engaging in scouting activities. The absorbed dose from the biological monitoring (as monitored in the study) for the five replicates of 4-hour scouting activities in cauliflower and tomatoes are 0.0022 and 0.00076 mg/kg/day, respectively. These absorbed doses (monitored 24 hours after treatment) correspond to MOEs of 14 and 39, respectively. Because the biological monitoring results at 24 hours after treatment are at a MOE < 100, a transfer coefficient approach is used to determine an entry restriction. The scout transfer coefficients are 738 and 677 cm^2/hr for cauliflower and tomatoes, respectively. To capture potential scouting exposures for all crops listed in the grouping matrix (see Table 5), the higher transfer coefficient of 738 cm^2/hr is used along with the DFR data for sugar beets because it exhibited the longest half live. Note: Cotton presented the highest intital residue level and the results of the postapplication exposure are similar to that of sugar beets. Table 7 provides the absorbed dose and MOEs for short- and intermediate-term exposure durations. As illustrated in Table 7 a 24 hour entry restriction is needed for scouts.

Table 7. Short- and Intermediate-Term MOEs for **Scouting** Various Crops Associated with the Grouping Matrix (see Table 5).

Exposure Duration	DAT[a]	Sugar Beet DFR Data and Cauliflower Scouting Transfer Coefficient as Representative Scenario for all Low, Medium, and High Crop Groupings					
		1 lb ai/acre			2 lb ai/acre		
		DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]	DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]
Short-Term	0	0.600	0.051	99	2.4	0.202	25
	1	NA	NA	NA	0.133	0.0113	440
Intermediate- Term	0	0.600	0.0015	20	1.2	0.0030	10
	1	0.0333	8.4E-5	360	0.0667	0.00017	180

a DAT = Days after treatment.

b DFR ($\mu g/cm^2$): sugar beet data from MRID 447481-02 monitored at 1 lb ai/A and normalized (multiplied by 2) to account for the maximum application rate of 2 lb ai/A.

c Absorbed Dose (mg/kg/day) = (DFR x Tc (738 cm^2/hr) x 0.001 mg/μg conversion x 1.0 absorption factor for short-term and 0.03 for intermediate-term x 8

hrs/day) /70 kg
d MOE = NOAEL / Absorbed Dose (mg/kg/day); where short-term NOAEL is 5 mg/kg/day and intermediate-term is 0.03 mg/kg/day.

Cauliflower

Cauliflower REIs are being separated from the crop grouping matrix because of the chemical-specific DFR data available that indicate that the residues decline at a different rate. As presented in Section 3.1.2, the actual cauliflower DFR data match the linear prediction with an R^2 of 0.94. Based on these chemical-specific data, REIs are presented in Table 8. The REIs are for harvesting activities assessed at 1 and 2 lb ai/acre using HED's transfer coefficient policy of 2,500 cm^2/hour. The DFR, dermal dose, and MOE calculations are presented in Appendix B, Tables B9 through B12.

Table 8. Cauliflower Short- and Intermediate-Term REIs.

Short-Term REIs (days)		Intermediate-Term REIs (days)	
1 lb ai/A	2 lb ai/A	1 lb ai/A	2 lb ai/A
5	8	12	15

Table 9 presents the required entry restrictions for scouting. Chemical-specific DFR and activity-specific scouting data for cauliflower were used in the assessment.

Table 9. Cauliflower Short- and Intermediate-Term MOEs for **Scouting** .

Exposure Duration	DAT[a]	Cauliflower DFR and Activity-specific Transfer Coefficient (738 cm^2/hr)					
		1 lb ai/acre			2 lb ai/acre		
		DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]	DFR ($\mu g/cm^2$)[b]	Dose (mg/kg/day)[c]	MOE[d]
Short-Term	0	0.639	0.054	93	1.28	0.108	46
	1	0.497	0.042	120	0.995	0.084	60
	2	--	--	--	0.774	0.065	77
	3	--	--	--	0.603	0.051	98
Intermediate- Term	0	0.639	0.0016	19	1.28	0.0032	9
	1	0.497	0.0013	24	0.995	0.0025	12
	2	0.387	0.00098	31	0.774	0.0020	15
	3	0.301	0.00076	39	0.603	0.0015	20
	4	0.235	0.00059	51	0.469	0.0012	25
	5	0.183	0.00046	65	0.365	0.00092	32
	6	0.142	0.00036	83	0.284	0.00072	42
	7	0.111	0.00028	110	0.221	0.00056	54
	8	--	--	--	0.172	0.00044	69

	9	--	--	--	0.134	0.00034	88
	10	--	--	--	0.104	0.00026	110

a DAT = Days after treatment.
b DFR (μg/cm^2): cauliflower data from MRID 429745-01 monitored at 1 lb ai/A and normalized (multiplied by 2) to account for the maximum application rate of 2 lb ai/A.
c Absorbed Dose (mg/kg/day) = (DFR x Tc (738 cm^2/hr) x 0.001 mg/μg conversion x 1.0 absorption factor for short-term and 0.03 for intermediate-term x 8 hrs/day) /70 kg
d MOE = NOAEL / Absorbed Dose (mg/kg/day); where short-term NOAEL is 5 mg/kg/day and intermediate-term is 0.03 mg/kg/day

Citrus

The REIs and scouting entry restrictions for citrus, based on the data in MRID 430627-01, are presented in Appendix B, Tables B5 and B6 for short- and intermediate-term durations, respectively. In addition to the chemical-specific DFR data and measured transfer coefficients for pruners and harvesting, HED's default transfer coefficient of 1,000 cm^2/hr is used to assess scouting activities in citrus. The transfer coefficients were developed by the registrant (verified by HED) using the passive dosimetry portion of the data submission. The average harvesting transfer coefficient is 6,891 cm^2/hr (range 6,650 to 7,494 cm^2/hr); average pruner in rainy conditions is 3,213 cm^2/hr (range 2,337 to 3,929 cm^2/hr); and average pruner in dry conditions is 1,371 cm^2/hr (range 1,121 to 1,673 cm^2/hr). The harvesting REI is presented as a high-end postapplication activity, even though the timing of the citrus application (i.e., early season) and long preharvest interval (PHI) may render the REI for harvesting inconsequential. Table 10 presents the summary of the citrus reentry intervals (REIs) and scouting entry restrictions as presented in detail in Appendix B. The REI and scouting entry restrictions are set at the day after treatment (DAT) that the MOE is 100 or greater. Duration of exposure activities (i.e., days engaged in scouting, pruning, and harvesting) are presumed to be of an intermediate-term duration. Nonetheless, Table 10 presents both the short-term (1 to 7 days) and intermediate-term (7 days to several months) assessment of REIs and scouting entry restrictions.

Table 10. Summary of the Short- and Intermediate-Term REIs for Citrus Worker Activities.

Activity	Short-Term REIs (days)	Intermediate-Term REIs (days)
Scouts (entry restrictions)	1 to 2	4
Pruning (wet conditions)	3 to 4	6
Pruning (dry conditions)	2	3
Harvesting	4 to 5	5 to 6

Tree Nuts & Fruits

Chemical-specific DFR data are available for almonds, apples, and pecans (see *Postapplication Exposure Section*). The assessment for almonds, apples, and pecans are believed to be an adequate surrogate to represent other tree nuts and fruits such as filberts, walnuts, pears, plums, prunes, and peaches. The tree fruit treatments are limited to applications during the dormant to early season (EPA Reg. No. 62719-220). Although the timing of the tree nut applications are such that harvesting REIs are not necessary (i.e., early season applications), they are provided to represent the high-end postapplication activities until such time that the ARTF data are provided for other activities.

The citrus data (transfer coefficients only) in MRID 430627-01 are used as surrogate data to assess the harvesting REIs for tree nuts and fruits. This assessment is only meant to be a range-finder until specific activities are identified (e.g., pecans are not harvested by hand but rather shaken from the tree and potential exposure results from the windrowing process) and the transfer coefficients determined. The REI assessment is presented in Appendix B, Tables B7 and B8 for short- and intermediate-term durations, respectively. Table 11 presents the summary of the reentry intervals (REIs) and scouting entry restrictions as presented in detail in Appendix B. The REI is set at the day after treatment (DAT) that the MOE is 100 or greater. Duration of exposure activities (i.e., days engaged in scouting and harvesting) are presumed to be of an intermediate-term duration. Nonetheless, Table 11 presents both the short-term (1 to 7 days) and intermediate-term (7 days to several months) assessment of REIs and scouting entry restrictions.

Table 11. Summary of the Short- and Intermediate-Term Reentry Intervals (REIs) for Tree Nut & Fruit Worker Activities.

Activity	Short-Term REIs (days)			Intermediate-Term REIs (days)		
	Almonds	Apples	Pecans	Almonds	Apples	Pecans
Scouts (entry restriction)	1	1	0	4	2 to 3	0
Harvesting	4 to 5	3	1	7	5	3 to 4

3.2.2 Insufficient Data

At this time, there are insufficient data to adequately address the REIs for (1) turf harvesting at sodfarms (the Agency is currently analyzing recently submitted turf DFR data), (2) tree nuts (REI assessment in this document uses the DFR data for almonds and pecans but is only a range-finder assessment because tree nuts are not harvested by hand and accurate transfer coefficients for activity specific tasks are not available) , (3) ornamental uses, and (4) soil incorporated uses. First, turf dissipation data have been recently submitted (MRID 448296-01) and HED is currently analyzing the data. The existing data (MRID 430135-01) for turf residues are insufficient to calculate dissipation over time. Second, a new DFR study for apples, almonds, and pecans (MRID No. 447481-01) has been recently submitted and not yet reviewed, preliminary results are included in this document. The surrogate assessment for tree nuts and fruits will be revised using transfer coefficient data once they have completed by the ARTF. Third, the ornamental uses are of concern, specifically postapplication activities such as pruning, transplanting, and burlap/balling. The ornamental application rates range up to 0.16 lb ai/gallon for pine seedlings (Reg. No. 34704-66-65783). There are insufficient information concerning the timing of the applications in relation to the postapplication activities and a lack of residue data (foliar and bark treatments) to assess the REIs for the ornamental uses. Finally, the soil incorporated uses that may involve postapplication exposures (e.g., planting tobacco within 24 hours of treatment) are also of concern. Based on these concerns and lack of data, HED recommends that a REI be set using a comparable interval (or the maximum interval) calculated from the existing data for other uses until more information is submitted by the registrant.

Finally, the Agency estimates that postapplication exposures following applications of eartags to livestock would be minimal. Worker contact with the eartags after they are applied would be

incidental and rare. Therefore, no postapplication exposure and risk assessment are warranted and no entry restrictions apply.

4.0 ADDITIONAL OCCUPATIONAL EXPOSURE STUDIES

Handler Studies

Risk mitigation measures need to be discussed with the registrant prior to requesting any additional handler exposure studies.

Post-Application Studies

Risk mitigation measures need to be discussed with the registrant along with reviewing the Agricultural Reentry Task Force data prior to requesting any additional postapplication exposure studies.

APPENDIX A

INTERMEDIATE-TERM HANDLER EXPOSURE/RISK

TABLES A1 THROUGH A4

Table A1. Passive Dosimetry: Maximum PPE Intermediate-Term Dermal, Inhalation, and Total MOEs for (Ag Uses) Chlorpyrifos.

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure ($\mu g/cm^2$) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Mixer/Loader Exposure								
Mixing/loading liquids for aerial and/or chemigation applications (1a)	0.017	0.24	Cranberries/corn 1.5	0.0038	8	0.0018	56	7
			Citrus 3.5	0.0026	12	0.0012	83	10
Mixing/loading liquids for groundboom application (1b)			Predominant max 1.5	0.00087	34	0.00041	240	30
			Tobacco 5.0	0.0029	10	0.0014	73	9
			Sodfarm 2.0 (tobacco/potato)	0.0012	26	0.00055	180	23
			Sodfarm 4.0	0.0023	13	0.0011	91	11
			Sodfarm 8.0 (fire ant) @ <1 acre	0.00006	510	0.00003	3,600	450
			Sodfarm 8.0 (fire ant) @ 10 acres	0.00058	51	0.00027	360	45
Mixing/loading liquids for airblast application (1c)			Citrus 6.0	0.0018	17	0.00082	120	15
			Predominant max 2.0 (orchards)	0.00058	51	0.00027	360	45
Mixing WP for Aerial and/or chemigation Applications (2a)	See engineering controls	See engineering controls	Predominant max 2.0 (orchards)	DAS is not supporting the WP formulation in open bag packaging; see engineering controls for the assessment of water soluble packets				
			Citrus 3.5					
Mixing WP for Groundboom Application (2b)			Predominant max (brassica) 1.0					
			Sodfarm 8.0 (fire ant) @ <1 acre					
			Sodfarm 8.0 (fire ant)@ 10 acres					
			Sodfarm 1.3					
			Sodfarm 3.0					
			Ornamental 4.0					
Mixing WP for Airblast Application (2c)			Predominant max 2.0 (orchards)					
			Citrus 6.0					

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure ($\mu g/cm^2$) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Loading Granulars for Aerial Application (3a)	0.0034	0.34	Max. 1.95	0.00099	30	0.0033	30	15
Loading Granulars for Ground Application (3b)			Tobacco max. 3.0	0.00035	86	0.0012	86	43
			Corn typical 1.0	0.00012	260	0.00039	260	130
			Corn max 2.0	0.00023	130	0.00078	130	64
Applicator Exposure								
Aerial (Liquids) -- Enclosed Cockpit (4a)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Aerial (Granulars) -- Enclosed Cockpit (4b)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Groundboom Tractor (5)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Airblast Applicator (6)	See engineering controls	See engineering controls	See engineering controls	See engineering controls.	See engineering controls	See engineering controls	See engineering controls	See engineering controls
Tractor-Drawn Granular Spreader (7)	0.0099 (baseline)	0.24	Tobacco max. 3.0	0.00043	69	0.00082	120	44
			Corn typical 1.0	0.00014	210	0.00027	360	130
			Corn max 2.0	0.00029	100	0.00055	180	66
Seed Treatment (8)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dip Application (Preplant Peaches) (9)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Flagger Exposure								
Spray Applications (10)	0.011 (Baseline)	0.07	Predominant max 2.0	0.0030	10	0.00070	140	9
			Citrus 3.5	0.0015	20	0.00035	290	19
Granular Applications (11)	NA	NA	Max. 1.95	0.00047	64	0.00029	340	54

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai) [a]	Inhalation Unit Exposure ($\mu g/cm^2$) [b]	Application Rate (lb ai/A)	Dermal - Maximum PPE [b, e]		Inhalation - Maximum PPE [c, e]		Total MOE
				Daily Dose (mg/kg/day)	MOE	Daily Dose (mg/kg/day)	MOE	
Mixer/Loader/Applicator Exposure								
Backpack Sprayer (12)	1.6	6	Predominant max 0.0417 lb ai/gal	0.0011	26	0.00014	700	25
			Bark beetle 0.08 lb ai/gal	0.0022	14	0.00027	360	13
			Citrus Bark 3.5	0.0024	13	0.00030	330	12
			Stump 0.03 lb ai/gal	0.00082	36	0.00010	970	35
			Animal premise 0.000052 lb ai/ft2	0.00004	840	0.00000	22,000	810
Low Pressure Handwand (13)	0.37	6	Predominant max 0.0417 lb ai/gal	0.00026	110	0.00014	700	98
			Bark beetle 0.08 lb ai/gal	0.00051	59	0.00027	360	51
			Citrus Bark 3.5	0.00056	54	0.00030	330	47
			Stump 0.03 lb ai/gal	0.00019	160	0.00010	970	140
			Animal premise 0.000052 lb ai/ft2	0.00001	3,600	0.00000	22,000	3,100
High Pressure Handwand (14)	1.6	24	Min. 0.0033 lb ai/gal	Min. 0.0023	13	0.0011	88	12
			Max. 0.0066 lb ai/gal	Max. 0.0045	7	0.0023	44	6
Tree Trunk Spray (15)	0.31	1	Citrus Bark 3.5	0.0093	3	0.0010	100	3
			Bark beetle 0.08 lb ai/gal	0.011	3	0.0011	88	3
			Pine seedling 0.16 lb ai/gal	0.021	1	0.0023	44	1
			Animal premise 0.000052 lb ai/ft2	0.00007	430	0.00001	13,000	420

[a] Max. PPE unit exposures represent the use of open systems (e.g., open pour mixing and open cab tractors) coveralls over long pants, long sleeved shirt, chemical-resistant gloves, and a dust/mist respirator (5-fold protection factor), except scenarios 8 and 11 which represents baseline dermal attire (i.e., long pants, long sleeved shirt, and no gloves) and a dust/mist respirator (5-fold protection factor).

[b] Max. PPE dermal daily dose (mg/kg/day) = [Maximum PPE dermal unit exposure (mg/lb ai) * Appl. rate (lb ai/acre) * Acres treated * 0.03 dermal absorption] / Body weight (70 kg).

[c] Max. PPE inhalation daily dose (mg/kg/day) = [inhalation unit exposure (mg/lb ai) * 0.001 μg/mg unit conversion * max appl rate (lb ai/A or lb ai/gal) * area treated (acres or gal) * 1 inhalation absorption] / Body weight (70 kg).

[e] MOE = NOAEL (mg/kg/day) / Daily Dose [Where Dermal NOAEL = 0.03 mg/kg/day and Inhalation NOAEL = 0.1 mg/kg/day]. MOE of 100 is considered acceptable.

[d] Max. PPE Total MOE = 1/((1/Dermal MOE) + (1/Inhalation MOE)).

Table A2. Passive Dosimetry: Eng. Controls Intermediate-Term Dermal, Inhalation, and Total MOEs for (Ag Uses) Chlorpyrifos.

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure ($\mu g/cm^2$)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Mixer/Loader Exposure								
Mixing/loading liquids for aerial application (1a)	0.0086 (gloves)	0.083	Cranberries/corn 1.5	0.0019	16	0.00062	160	14
			Citrus 3.5	0.0013	23	0.00042	240	21
Mixing/loading liquids for groundboom application (1b)			Predominant max 1.5	0.00044	68	0.00014	700	62
			Tobacco 5.0	0.0015	20	0.00047	210	19
			Sodfarm 2.0 (tobacco/potato)	0.00059	51	0.00019	530	46
			Sodfarm 4.0	0.0012	25	0.00038	260	23
			Sodfarm 8.0 (fire ant) @ <1 acre	0.00003	1,000	0.00001	11,000	930
			Sodfarm 8.0 (fire ant) @ 10 acre	0.00029	100	0.00009	1,100	93
Mixing/loading liquids for airblast application (1c)			Citrus 6.0	0.00088	34	0.00028	350	31
			Predominant max 2.0	0.00029	100	0.00009	1,100	93
Mixing WP for Aerial Application (2a)	0.0098 (gloves)	0.24	Predom. max 2.0 (orchards)	0.0029	10	0.0024	42	8
			Citrus 3.5	0.0015	20	0.0012	83	16
Mixing WP for Groundboom Application (2b)			Predominant max (brassica) 1.0	0.00034	89	0.00027	360	72
			Sodfarm 1.3	0.00044	69	0.00036	280	55
			Sodfarm 3.0	0.0010	30	0.00082	120	24
			Ornamental 4.0	0.00017	180	0.00014	730	140
			Sodfarm 8.0 (fire ant) @ <1 acre	0.00003	890	0.00003	3,600	720
			Sodfarm 8.0 (fire ants)@ 10 acre	0.00034	89	0.00027	360	72
Mixing WP for Airblast Application (2c)			Predominant max 2.0	0.00034	89	0.00027	360	72
			Citrus 6.0	0.0010	30	0.00082	120	24

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure ($\mu g/cm^2$)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Loading Granulars for Aerial Application (3a)	0.00017	0.034	Max. 1.95	0.00005	600	0.00033	300	200
Loading Granulars for Ground Application (3b)			Tobacco max 3.0	0.00002	1,700	0.00012	860	570
			Corn typical 1.0	0.00001	5,100	0.00004	2,600	1,700
			Corn max 2.0	0.00001	2,600	0.00008	1,300	860
Applicator Exposure								
Aerial (Liquids) -- Enclosed Cockpit (4a)	0.005	0.068	Predom. max 2.0 (orchards)	0.0015	20	0.00068	150	17
			Citrus 3.5	0.00075	40	0.00034	290	35
Aerial (Granulars) -- Enclosed Cockpit (4b)	0.0016	1.3	Max. 1.95	0.00047	64	0.013	8	7
Groundboom Tractor (5)	0.005	0.043	Predominant max 1.5	0.00026	120	0.00007	1,400	110
			Tobacco 5.0	0.00086	35	0.00025	410	32
			Sodfarm 1.3	0.00022	130	0.00006	1,600	120
			Sodfarm 2	0.00034	88	0.00010	1,000	81
			Sodfarm 3	0.00051	58	0.00015	680	54
			Sodfarm 4	0.00069	44	0.00020	510	40
			Sodfarm 8.0 @ <1 acre	0.00002	1,800	0.000005	20,000	1,600
			Sodfarm 8.0 @ 10 acres	0.00017	180	0.00005	2,000	160
Airblast Applicator (6)	0.019 (gloves)	0.45	Orchards 2.0	0.00065	46	0.00051	190	37
			Citrus 6.0	0.0020	15	0.0015	65	12
Tractor-Drawn Granular Spreader (7)	0.0021	0.22	Tobacco max. 3.0	0.00022	140	0.00075	130	68
			Corn typical 1.0	0.00007	420	0.00025	400	200
			Corn max 2.0	0.00014	210	0.00050	200	100
Seed Treatment (8)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Dip Application (Preplant Peaches) (9)	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Flagger Exposure								
Spray Applications (10)	0.00022	0.007	Typical 2.0	0.00007	450	0.00007	1,400	340
			Citrus 3.5	0.00003	910	0.00004	2,900	690
Granular Applications (11)	NA	NA	NA	0.00002	1,800	0.00003	3,400	1,200

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)	Inhalation Unit Exposure ($\mu g/cm^2$)	Application Rate (lb ai/A)	Dermal - Engineering Controls		Inhalation - Engineering Controls		Total MOE[i]
				Daily Dose (mg/kg/day) [a]	MOE[b]	Daily Dose (mg/kg/day)[d]	MOE[e]	
Mixer/Loader/Applicator Exposure								
Backpack Sprayer (12)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
Low Pressure Handwand (13)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
High Pressure Handwand (14)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible
Tree Trunk Spray (15)	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible	Not Feasible

[a] Engineering control unit exposures represent long pants, long sleeved shirt, and no gloves (exception - scenarios 1a, 1b, 1c, 2 a, 2b, 2c, and 7 represent handlers wearing chemical-resistant gloves) while using closed mixing systems (98 percent protection factor used for a closed granular loader) and enclosed cockpits/cabs.

[b] Engineering control dermal daily dose (mg/kg/day) = [Engineering Controls dermal unit exposure (mg/lb ai) * Appl. rate (lb ai/acre) * Acres treated * 0.03 dermal absorption] / Body weight (70 kg).

[c] Engineering control inhalation daily dose (mg/kg/day) = [Inhalation unit exposure (mg/lb ai) * 0.001 μg/mg unit conversion * max appl rate (lb ai/A or lb ai/gal) * area treated (acres or gal) * 1 inhalation absorption] / Body weight (70 kg).

[e] MOE = NOAEL (mg/kg/day) / Daily Dose [Where Dermal NOAEL = 0.03 mg/kg/day and Inhalation NOAEL = 0.1 mg/kg/day]. MOE of 100 is considered acceptable.

[d] Engineering control Total MOE = 1/((1/Dermal MOE) + (1/Inhalation MOE)).

Table A3. Exposure Scenario Descriptions of the Exposure and Risk Mitigation Measures for Agricultural Uses of Chlorpyrifos	
Exposure Scenario (Number)	**Comments[b]**
Mixer/Loader Exposure	
Mixing All Liquids (1a,b,c)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Mixing Wettable Powder (2a,b,c)	
Loading Granulars (3a,b)	
Applicator Exposure	
Aerial equipment - enclosed cockpit (liquids) (4a)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Aerial equipment - enclosed cockpit (Granulars) (4b)	
Groundboom Tractor (5)	
Airblast Applicator (6)	
Tractor-drawn Granular Spreader (7)	
Seed Treatment (8)	No Data
Dip Application (Preplant Peaches) (9)	No Data

Table A3. Exposure Scenario Descriptions of the Exposure and Risk Mitigation Measures for Agricultural Uses of Chlorpyrifos	
Exposure Scenario (Number)	**Comments[b]**
Flagger	
Spray Applications (10)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Granular Applications (11)	
Mixer/Loader/Applicator	
Backpack Sprayer (12)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.
Low Pressure Handwand (13)	
High Pressure Handwand (14)	
Tree Trunk Sprayer (15)	The number of replicates and PHED grades are available in the PHED Surrogate Exposure Guide dated August 1998. For PPE a 50% protection factor (PF) was added for coveralls to the appropriate body locations, if necessary a 90 % PF was added for the addition of chemical resistant gloves.

Note: The Baseline exposure for mixer/loaders include chemical resistant gloves.

[a] Standard Assumptions based on an 8-hour work day as estimated by OREB. BEAD data were not available.

[b] "Best Available" grades are defined by OREB SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B, and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High =grades A and B and 15 or more replicates per body part;
Medium =grades A, B, and C and 15 or more replicates per body part; and
Low = grades A, B, C, D, and E or any combination of grades with less than 15 replicates.

Table A4. Intermediate-Term Biological Monitoring for Agricultural Uses of Chlorpyrifos

Exposure Scenario (Number)[a]	Average Unit Dose[b] (mg/kg/lb ai)	Amount ai handled[c]		Clothing and Equipment Scenario Monitored	No. of Obs.	Daily Dose[d] (mg/kg/day)	MOE[e]
		Rate (lb ai/A)	Acres				
Mixer/Loader Risk							
Mixing Liquids for Aerial Application (1a)	3×10^{-6} (lognormal - geo mean)	1.5	350	Open pour liquids; cotton coveralls, cotton T-shirt, briefs, socks, eye protection, chemical-resistant nitrile gloves, chemical-resistant apron, and chemical-resistant knee high boots	14	0.0016	19
		4.0	350			0.0042	7
		3.5	100			0.0011	27
Mixing All Liquids for Groundboom Application (1b)	6.7×10^{-5}	1.5	80	Open pour liquids; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	3	0.0080	4
Mixing All Liquids for Airblast Application (1c)	6.0×10^{-5}	1.5	40	Open pour liquids; denim coveralls over short-sleeved shirt, long-pants, T-shirt and briefs, chemical resistant gloves, and a respirator	15	0.0036	8
Mixing WP for Groundboom Application (2b)	3.9×10^{-4}	2.0	80	Open pour wettable powder; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, chemical resistant gloves, and ½ face respirator	6	0.062	0.5
Applicator Risk							
Groundboom Tractor (6)	6.1×10^{-5}	2.0	80	Open cab; cotton coveralls over T-shirt and briefs, and baseball cap	9	0.0098	3
Airblast (7)	9.1×10^{-5}	2.0	40	Open cab; denim coveralls over short-sleeved shirt, long-pants, T-shirt and briefs, chemical resistant gloves, and a respirator	15	0.0073	4
Mixer/Loader/Applicator Risk							
Granular Loading Combined with Tractor-Drawn Spreader (Scenarios 3b and 8 combined)	1.0×10^{-5}	Typ. 1.0	80	enclosed cab, various configurations of closed windows to open doorways; cotton coveralls over T-shirt and briefs, socks and shoes	12	0.0008	38
		Max 2.0				0.0016	19

Table A4. Intermediate-Term Biological Monitoring for Agricultural Uses of Chlorpyrifos

Exposure Scenario (Number)[a]	Average Unit Dose[b] (mg/kg/lb ai)	Amount ai handled[c]		Clothing and Equipment Scenario Monitored	No. of Obs.	Daily Dose[d] (mg/kg/day)	MOE[e]
		Rate (lb ai/A)	Acres				
Backpack (Greenhouse) (13)	2.7×10^{-3}	0.0417 lb ai/gal	40	Solo backpack sprayer; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	2	0.0045	7
Low Pressure Handwand (Greenhouse) (14)	1.7×10^{-3}	0.0417 lb ai/gal	40	Gilmour 101P, manual sprayer; cotton coveralls over T-shirt and briefs, rubber boots, baseball cap, and chemical resistant gloves	1	0.0028	11
High Pressure Handwand (Greenhouse) (15)	3.7×10^{-3}	Min. 0.0031 lb ai/gal	1,000 gal/day	Six of the 13 test subjects wore neoprene rain jacket/pants, ½ face respirator, face shield, cotton coveralls over T-shirt and briefs, and chemical resistant gloves. The remaining 7 test subjects wore cotton coveralls over T-shirt and briefs, and chemical resistant gloves.	13	Min. 0.011	Min. 3
		Max. 0.0063 lb ai/gal				Max. 0.023	Max. 1

[a] Data source for exposure scenarios 1a is MRID 447393-02; 1b, 2b, 6 is MRID No. 429745-01; exposure scenarios 1c and 7 is MRID No. 431381-02; exposure scenarios 13, 14, and 15 is MRID No. 430279-01; and exposure scenarios 3b and 8 combined is MRID No. 444835-01.

[b] All unit dose values are reported as the arithmetic means; except scenario 1a (lognormal -- geo. Mean). The results are reported as "unit doses" to extrapolate to the label maximum rates.

[c] Application rates are the maximum labeled rates found on EPA Reg. Nos. 62719-163, -39, -221, -23, -245, -255 -34 -79 -72 -166 -220; 34704-66; and greenhouse label 499-367. Not all rates are reflected from Table 3 because none of the MOEs approach 100. Daily acres treated are based on HED's estimates of acreage that would be reasonably expected to be treated in a single day for each exposure scenario of concern.

[d] Daily Dose (mg/kg/day) = Unit Dose (mg/kg/lb ai) x Appl. Rate (lb ai/A or lb ai/gal) x Amount handled (acres or gallons).

[e] MOE = NOAEL / Daily Dose (mg/kg/day). NOAEL = 0.03 mg/kg/day (oral animal toxicity data). MOE of 100 is considered acceptable.

APPENDIX B

SHORT- AND INTERMEDIATE-TERM POSTAPPLICATION EXPOSURE/RISK

TABLES B1 THROUGH B8

Table B1. Short-Term Reentry Intervals (REIs) for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 1 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	0.60	0.171	29	1.25	0.57	9	1.1	1.3	4
1	0.033	0.0094	530	0.0308	0.014	360	0.0196	0.022	220

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion *1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B2. Intermediate-Term Reentry Intervals (REIs) for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 1 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]
0	0.60	0.0051	6	1.25	0.017	2	1.1	0.038	<1
1	0.0333	0.00029	100	0.0308	0.00042	71	0.0196	0.00067	45
2	-	-	-	0.0162	0.00022	140	0.0107	0.00037	82
3	-	-	-	-	-	-	0.0059	0.00020	150

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B3. Short-Term Reentry Intervals (REIs) for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 2 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	2.4	0.69	7	A 2 lb ai/acre rate was not identified for the crops in this grouping			2.2	2.5	2
1	0.133	0.038	130				0.0392	0.045	110

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B4. Intermediate-Term Reentry Intervals (REIs) for Potential Dermal Contact Rates and Crop Groupings Based on an Application Rate of 2 lb ai/acre.

DAT[a]	Low Exposure Potential[b] Tc = 2,500 cm^2/hour			Medium Exposure Potential[b] Tc = 4,000 cm^2/hour			High Exposure Potential[b] Tc = 10,000 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]
0	1.2	0.010	3	A 2 lb ai/acre rate was not identified for the crops in this grouping			2.2	0.075	<1
1	0.0667	0.00057	52				0.0392	0.0013	22
2	0.0423	0.00036	83				0.0214	0.00073	41
3	0.027	0.00023	130				0.0119	0.00041	74
4	-	-	-				0.00667	0.00023	130

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Potential dermal contact rates (i.e., "Low, Medium, and High") coincide with HED's policies for agricultural default transfer coefficients and available DFR data.

c DFR data from MRID 447481-02 where "Low" is represented by sugar beets, "Medium" is represented by cotton, and "High" is represented by sweet corn. DFR data are based on an application rate of 1 lb ai/A.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for "Low" is HED's default of 2,500 cm^2/hr; "Medium" is HED's default of 4,000 cm^2/hr; "High" is HED's default of 10,000 cm^2/hr.

e MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B5. Short-Term Reentry Intervals (REIs) for Scouts, Pruners, and Harvesters in Chlorpyrifos Treated Citrus Orchards.

DAT[a]	DFR[c] (μg/cm^2)	Scouts[b] Tc = 1,000 cm^2/hour		Wet Pruners[b] Tc = 3,213 cm^2/hour		Dry Pruners[b] Tc = 1,371 cm^2/hour		Harvesting[b] Tc = 6,891 cm^2/hour	
		Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day)	MOE[e]	Dose[d] (mg/kg/day	MOE[e]
0	0.947	0.11	46	0.35	14	0.15	34	0.75	7
1	0.520	0.059	84	0.19	26	0.082	61	0.41	12
2	0.286	0.033	150	0.10	48	0.045	110	0.23	22
3	0.157	-	-	0.058	87	-	-	0.12	40
4	0.086	-	-	0.032	160	-	-	0.068	74
5	0.047	-	-	-	-	-	-	0.037	130

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Citrus scout transfer coefficient is HED's default, pruners and harvester transfer coefficient are based on the data in MRID 430627-01.

c Citrus DFR data are from MRID 430627-01 (all three sites combined); the DFR data were generated at the maximum labeled rate of 6 lb ai/A, no application rate adjustments necessary.

d Daily Dermal Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr; wet pruning is 3,213 cm^2/hr; dry pruning is 1,371 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Daily Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B6. Intermediate-Term Reentry Intervals (REIs) for Scouts, Pruners, and Harvesters in Chlorpyrifos Treated Citrus Orchards.

DAT[a]	DFR[c] (μg/cm^2)	Scouts[b] Tc = 1,000 cm^2/hour		Wet Pruners[b] Tc = 3,213 cm^2/hour		Dry Pruners[b] Tc = 1,371 cm^2/hour		Harvesting[b] Tc = 6,891 cm^2/hour	
		Abs. Dose[d] (mg/kg/day)	MOE[e]	Abs. Dose[d] (mg/kg/day)	MOE[e]	Abs. Dose[d] (mg/kg/day)	MOE[e]	Abs. Dose[d] (mg/kg/day	MOE[e]
0	0.947	0.0032	9	0.010	3	0.0045	7	0.022	1
1	0.520	0.0018	17	0.0057	5	0.00082	37	0.0041	7
2	0.286	0.00098	31	0.0031	10	0.00045	67	0.0023	13
3	0.157	0.00054	56	0.0017	17	0.00025	120	0.0012	24
4	0.086	0.00030	100	0.00095	32	-	-	0.00068	44
5	0.047	-	-	0.00052	58	-	-	0.00037	81
6	0.026	-	-	0.00029	100	-	-	0.00020	150

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Citrus scout transfer coefficient is HED's default, pruners and harvester transfer coefficient are based on the data in MRID 430627-01.

c Citrus DFR data are from MRID 430627-01 (all three sites combined); the DFR data were generated at the maximum labeled rate of 6 lb ai/A, no application rate adjustments necessary.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr; wet pruning is 3,213 cm^2/hr; dry pruning is 1,371 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B7. Short-Term Reentry Intervals (REIs) for Scouts and Harvesters in Chlorpyrifos Treated Tree Nut & Fruit Orchards.

DAT[a]	DFR[c] (μg/cm^2)	Scouts[b] Tc = 1,000 cm^2/hour						Harvesting[b] Tc = 6,891 cm^2/hour					
		Dose[d] (mg/kg/day)			MOE[e]			Dose[d] (mg/kg/day)			MOE[e]		
		Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan
0	0.834	0.095	0.077	0.0096	52	64	520	0.66	0.53	0.066	8	9	76
1	0.458	0.052	0.035	-	96	140	-	0.36	0.24	0.038	14	21	130
2	0.251	0.029	-	-	170	-	-	0.20	0.11	-	25	46	-
3	0.138	-	-	-	-	-	-	0.11	0.050	-	46	100	-
4	0.076	-	-	-	-	-	-	0.060	-	-	84	-	-
5	0.041	-	-	-	-	-	-	0.033	-	-	150	-	-

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Scout transfer coefficient is HED's default, citrus harvester transfer coefficient based on the data in MRID 430627-01. These Tc are used as a range-finder to assess potential high-end exposure; nut crops such as pecans are not harvested by hand, therefore, activity-specific transfer coefficients will be used when the ARTF submit the appropriate data.

c DFR data from MRID 447481-01 (all three sites combined) are used; data are preliminary, they are currently under review by HED.

d Daily Dermal Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Daily Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B8. Intermediate-Term Reentry Intervals (REIs) for Scouts and Harvesters in Chlorpyrifos Treated Tree Nut & Fruit Orchards.

DAT[a]	DFR[c] (μg/cm^2)	Scouts[b] Tc = 1,000 cm^2/hour						Harvesting[b] Tc = 6,891 cm^2/hour					
		Dose[d] (mg/kg/day)			MOE[e]			Dose[d] (mg/kg/day)			MOE[e]		
		Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan	Almond	Apple	Pecan
0	0.834	0.0029	0.0023	0.00029	10	13	100	0.020	0.016	0.0020	2	2	15
1	0.458	0.0016	0.0011	-	19	29	-	0.011	0.0073	0.0012	3	4	26
2	0.251	0.00086	0.00048	-	35	63	-	0.0059	0.0033	0.00067	5	9	45
3	0.138	0.00047	0.00022	-	63	140	-	0.0033	0.0015	0.00039	9	20	77
4	0.076	0.00026	-	-	120	-	-	0.0018	0.00068	0.00023	17	44	130
5	0.041	-	-	-	-	-	-	0.00098	0.00031	-	31	98	-
6	0.023	-	-	-	-	-	-	0.00054	-	-	56	-	-
7	0.012	-	-	-	-	-	-	0.00030	-	-	100	-	-

Note: Values rounded; calculations are based on spreadsheets.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Scout transfer coefficient is HED's default, citrus harvester transfer coefficient based on the data in MRID 430627-01. These Tc are used as a range-finder to assess potential high-end exposure; nut crops such as pecans are not harvested by hand, therefore, activity-specific transfer coefficients will be used when the ARTF submit the appropriate data.

c DFR data from MRID 447481-01 (all three sites combined) are used; data are preliminary, they are currently under review by HED.

d Daily Dermal Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) for scouts is HED's default of 1,000 cm^2/hr and harvesting is 6,891 cm^2/hr.

e MOE = oral NOAEL 0.03 (mg/kg/day) / Daily Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B9. Short-Term Reentry Intervals (REIs) for Cauliflower at an Application Rate of 1 lb ai/acre.

DAT[a]	Exposure Potential[b] Tc = 2,500 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	0.639	0.18	27
1	0.497	0.14	35
2	0.387	0.11	45
3	0.301	0.086	58
4	0.23	0.067	75
5	0.183	0.052	96

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Transfer coefficient is from HED's policies for default transfer coefficients.

c DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A.

d Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion *1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) is HED's default of 2,500 cm^2/hr.

Table B10. Intermediate-Term Reentry Intervals (REIs) for Cauliflower at an Application Rate of 1 lb ai/acre.

DAT[a]	Exposure Potential[b] Tc = 2,500 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]
0	0.639	0.0055	5
1	0.497	0.0043	7
2	0.387	0.0033	9
3	0.301	0.0026	12
4	0.235	0.0020	15
5	0.183	0.0016	19
6	0.142	0.0012	25
7	0.111	0.00095	32
8	0.086	0.00074	41
9	0.067	0.00058	52
10	0.052	0.00045	67
11	0.041	0.00035	86
12	0.032	0.00027	110

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Transfer coefficient is from HED's policies for default transfer coefficients.

c DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) is HED's default of 2,500 cm^2/hr.

Table B11. Short-Term Reentry Intervals (REIs) for Cauliflower at an Application Rate of 2 lb ai/acre.

DAT[a]	Exposure Potential[b] Tc = 2,500 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Dose[d] (mg/kg/day)	MOE[e]
0	1.278	0.37	14
1	0.995	0.28	18
2	0.774	0.22	23
3	0.603	0.17	29
4	0.469	0.13	37
5	0.365	0.10	48
6	0.284	0.081	62
7	0.221	0.063	79
8	0.172	0.049	100

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Transfer coefficient is from HED's policies for default transfer coefficients.

c DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A and normalized to 2 lb ai/acre.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 1 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) is HED's default of 2,500 cm^2/hr.

e MOE = 21-Day Dermal Rat NOAEL 5 (mg/kg/day) / Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.

Table B12. Intermediate-Term Reentry Intervals (REIs) for Cauliflower at an Application Rate of 2 lb ai/acre.

DAT[a]	Exposure Potential[b] Tc = 2,500 cm^2/hour		
	DFR[c] ($\mu g/cm^2$)	Abs. Dose[d] (mg/kg/day)	MOE[e]
0	1.278	0.011	3
1	0.995	0.0085	4
2	0.774	0.0066	5
3	0.603	0.0052	6
4	0.469	0.0040	7
5	0.365	0.0031	10
6	0.284	0.0024	12
7	0.221	0.0019	16
8	0.172	0.0015	20
9	0.134	0.0012	26
10	0.104	0.00090	34
11	0.081	0.00070	43
12	0.063	0.00054	55
13	0.049	0.00042	71
14	0.038	0.00033	91
15	0.030	0.00026	120

Note: Values rounded; calculations are based on spreadsheet analyses.

a Days after treatment (DAT). Workers wearing long pants, long sleeved shirts, and no gloves.

b Transfer coefficient is from HED's policies for default transfer coefficients.

c DFR data from MRID 429745-01 for cauliflower are based on an application rate of 1 lb ai/A and normalized to 2 lb ai/acre.

d Absorbed Dose (mg/kg/day) = [DFR * Tc * 0.001 mg/μg unit conversion * 0.03 dermal absorption * 8 hrs/day] / 70 kg body weight. Where: Transfer coefficient (Tc) is HED's default of 2,500 cm^2/hr.

e MOE = Oral (Animal) NOAEL 0.03 (mg/kg/day) / Absorbed Dermal Dose (mg/kg/day). A MOE of 100 is considered acceptable to set the REI.